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The Apparatus of *Gondolella sublanceolata* Gunnell (Conodontophorida, Upper Pennsylvanian) and its Relationship to *Illinella typica* Rhodes

Peter H. von Bitter

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PETER H. VON BITTER is Assistant Curator, Department of Invertebrate Palaeontology, Royal Ontario Museum.

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The Apparatus of *Gondolella sublanceolata* Gunnell (Conodontophorida, Upper Pennsylvanian) and its Relationship to *Illinella typica* Rhodes

Abstract

Examination of large collections of conodonts from Upper Pennsylvanian strata in Iowa has led to the conclusion that the skeletal apparatus of *Gondolella sublanceolata* Gunnell consisted of at least one pair of Sp elements, at least one pair of each of five morphologically distinct Oz, Lo, Hi, Ne, and Syn elements, and at least one symmetrical Tr element.

Such an element composition of a species of *Gondolella* seems inconsistent with the element plan of the natural assemblage genus *Illinella* Rhodes. Re-examination of the types of *I. typica* Rhodes suggests that this apparatus is generally incompletely preserved and that the problematical lonchodiform elements represent fragments of ramiform elements. The two pairs of lonchodiniform elements reported in *I. typica* are interpreted as corresponding to the Ne and Syn elements of *G. sublanceolata*. Elements considered morphologically identical or similar to the Sp, Oz, Lo, Hi, and Tr elements of *G. sublanceolata* can be recognized to varying degrees in the natural assemblages. The reconstructed apparatus of *G. sublanceolata,* consisting of six paired element types and one bilaterally symmetrical element, can probably be taken as representative for use as an element blueprint for species of the genus *Gondolella.*

The apparatus of G. *sublanceolata* cannot readily be recognized as one of the four apparatus types in the classification of Klapper and Philip. The Sp element seems most similar to Sp elements of species placed in the Icriodontidae (Type 4 apparatus), whereas the ramiform elements are similar to ramiform elements of apparatuses placed in the Cryptotaxidae (Type 2 Apparatus) and the Hibbardellidae (Type 3 Apparatus).

Introduction

Clark and Mosher (1966) in their survey of gondolelliform platform elements discussed a variety of taxonomic and distributional problems associated with these forms. They recognized that important taxonomic and evolutionary differences existed between "Pennsylvanian", "Permian", and "Triassic" forms. Some

of these differences have been formalized in recent years by the recognition of a number of gondolelliform genera.

Jones (MS 1938) was apparently the first to find a natural assemblage containing paired gondolelliform platform elements associated with paired ramiform elements. The specimen, from the Pennsylvanian Seminole Formation of Oklahoma, was not illustrated until 1956 (Jones, 1956, fig. 7.2, illustration 2). Rhodes (1952) provided the first published information that at least some gondolelliform platform elements were paired and had a number of paired non-platform elements associated with them. The natural assemblages on which this conclusion was based were named *Illinella typica* by Rhodes.

The partial blueprint provided by *Illinella* Rhodes, the constant association of certain elements with *Gondolella* in a very restricted stratigraphic (and environmental) interval, and certain unifying morphologic and colour features, as well as the presence of at least a partial symmetry transition, led me to the conclusion that the apparatus of the Pennsylvanian species, *G. denuda* Ellison, contained Oz and Hi? elements in addition to an Sp element (von Bitter, 1972). However, the apparatus of *Gondolella denuda* is atypical by comparison with that of other species of *Gondolella*, in that the Sp element either lacks a platform or bears one that is rudimentary. This made it of interest to determine the composition of an apparatus that contains more typical gondolelliform elements, i.e., those having broad platforms. In this paper I present and discuss data demonstrating that the apparatus of *Gondolella sublanceolata* Gunnell contained a complement of six paired elements associated with one or more bilaterally symmetrical elements.

Materials and Methods

The 3859 specimens that form the basis of this study were recovered by standard techniques described by Collinson (1963, 1965) and discussed by von Bitter (1972), from samples collected in the spring of 1972 from the Heebner Shale (Virgilian, Upper Pennsylvanian) of western Iowa (Fig. 1; Appendix). These specimens were mounted on standard micropalaeontological slides, and the abundance of each conodont element was then tabulated (Table 1). Selected specimens from Iowa, as well as comparative specimens from elsewhere, were photographed by standard photomicrography with a Zeiss Microscope and a Cambridge Scanning Electron Microscope.

The criteria used in reaching conclusions about the multi-element nature of the apparatus of *Gondolella sublanceolata* include:

1. Similarity of colour and the white matter distribution (Fig. 2).
2. Similarity of morphology (basal cavity and denticulation) (Fig. 2).
3. Similarity of distribution both stratigraphically and geographically (Table 1). The underlying and overlying members at localities 1 and 2 are the Leavenworth and Plattsmouth limestones, respectively. Elements of *Gondolella sublanceolata* have not been found in these units at these localities.
4. A similar increase or decrease of one element relative to the other elements in each of the six samples studied.

All figured and unfigured specimens, with the exception of those noted as belonging to the University of Illinois, Urbana, Illinois and the Field Museum, Chicago, Illinois, are in the micropalaeontological collections of the Royal Ontario Museum. The associated conodonts will be described in a future publication.

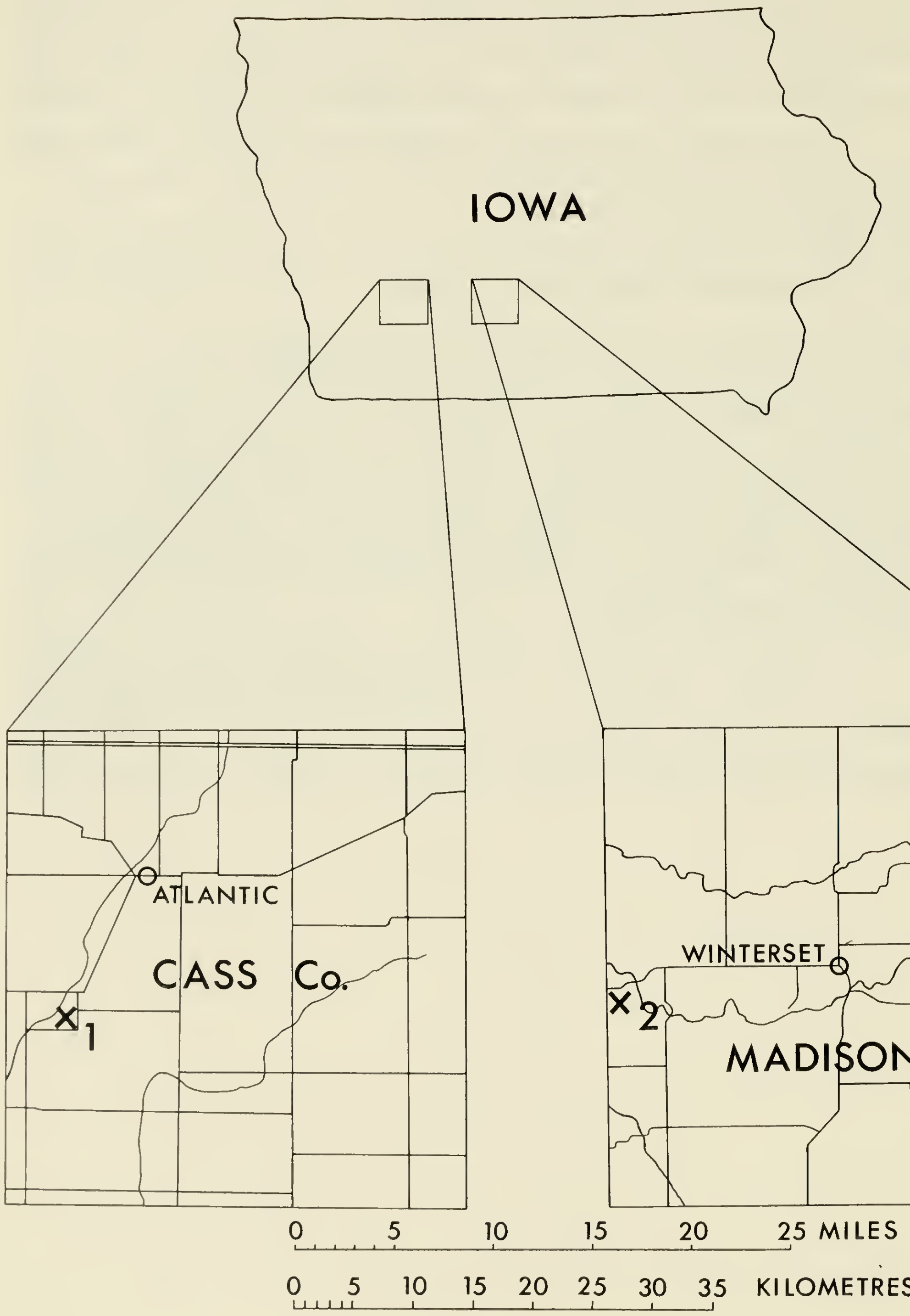


Fig. 1 Map showing localities 1 and 2, Iowa, U.S.A.

Order Conodontophorida Eichenberg, 1930
Superfamily Gondolellacea Lindström, 1970
Family Gondolellidae Lindström, 1970

Genus *Gondolella* Stauffer and Plummer, 1932

Gondolella Stauffer and Plummer, 1932: 41.
Illinella Rhodes, 1952: 898.

Type Species
Gondolella elegantula Stauffer and Plummer, 1932, by original designation.

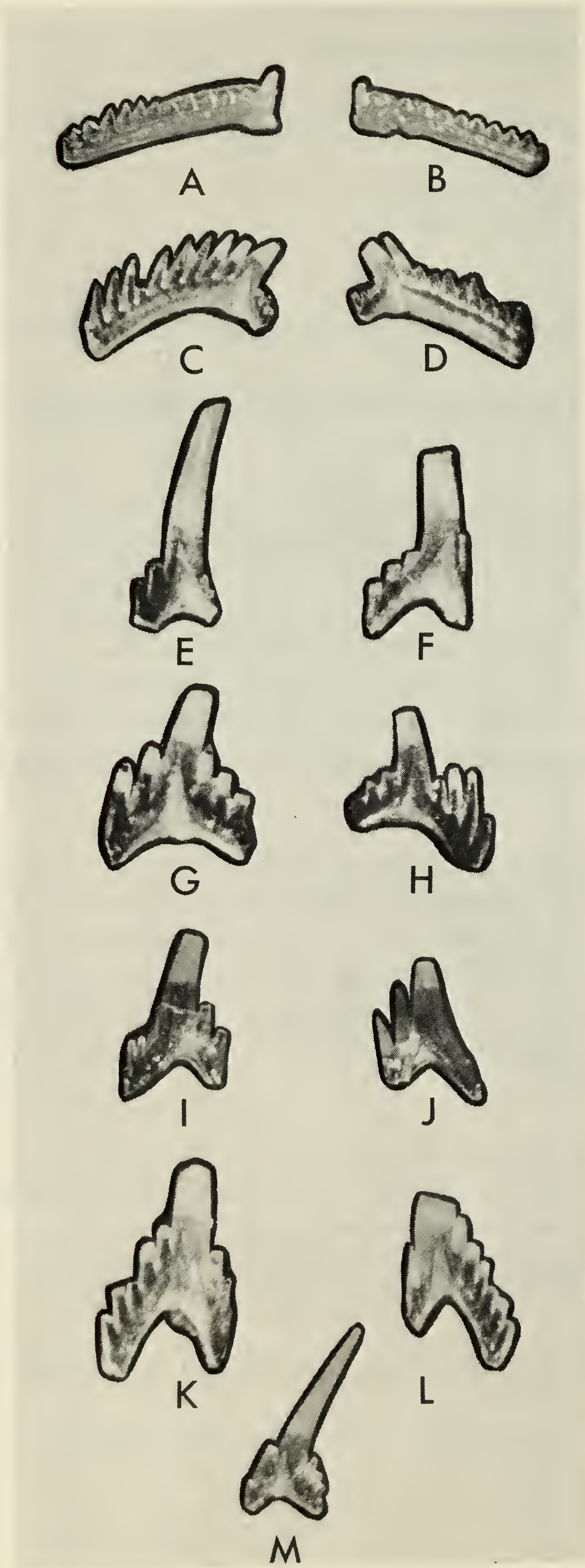
Gondolella sublanceolata Gunnell, 1933

Diagnosis
An apparatus containing paired Sp, Oz, Lo, Hi, Ne, and Syn elements as well as a probably unpaired bilaterally symmetrical Tr element. Sp element gondolelliform. White matter of elements restricted to the upper portion of the denticles and the cusp (Fig. 2). Basal cavities of all elements, other than possibly that of the Sp element, oriented at a noticeable angle to the cusp (Fig. 2). Platform element has a characteristic pitted microstructure which is restricted to the lateral edges of the platform. The six ramiform elements have a microstructure of both parallel and anastomosing ridges on their denticles and on their cusps.

Remarks
The element terminology used is basically that of Jeppsson (1971). The symbols for the Lo and Syn elements are derived from the genera *Lonchodina* and *Synprioniodina*. It should also be noted that the reconstruction of the apparatus of *G. sublanceolata* here presented is derived from samples taken at localities other than the type locality of the species. Thus the validity of the conclusions reached may be tested by sampling the type stratum of this species.

Sp element (Figs. 2A, B; 3; 4)
Synonymy in Clark and Mosher (1966) and Sweet (*in* Ziegler, 1973).
Gondolella sublanceolata – Lindström, 1973: 94.
P element (*Gondolella sublanceolata*) – Baesemann, 1973: 708.

Description
Full descriptions are given in Clark and Mosher (1966) and Sweet (*in* Ziegler, 1973).


A
B
C
D
E
F
G
H
I
J
K
L
M

Discussion

The variation in symmetry in this element during ontogenetic development has been mentioned by Clark and Mosher (1966). In the collections at hand this is expressed as asymmetry and is usually found in the larger specimens. The shortened platform causing this asymmetry is always on the left-hand side of the element (Fig. 3G, H). Medium and small-sized specimens show this feature only rarely. This is principally because the free blade is most strongly developed in large specimens, and is weak in intermediate and small specimens. The number of denticles varies considerably with size. Small specimens (Fig. 3F) may have as few as three denticles, not counting the cusp, whereas a large element may bear 13 or more denticles (Fig. 3A). The importance of not basing conodont species on small elements may be appreciated from an examination of Fig. 3A–F, which shows a gradual development and widening of the platform with an increase in size. Concomitant with an increase in the size there is, as was recognized by Clark and Mosher (1966: 387), a change in ornamentation. Small forms are essentially unornamented (Fig. 3F). With an increase in size there is an accompanying development of transverse ridges (Fig. 3B). In large specimens there is development of a second-order row of transverse ridges (Fig. 3H), which culminate in extremely complex ornamentation (Fig. 3A).

The denticles and the cusp are laterally compressed and are sharp edged anteriorly and posteriorly. The denticles reach their maximum height on the free blade. A small denticle is present posterior to the cusp on many specimens (Fig. 3B). Although the denticles are generally clear and of an amber colour the cusp shows the characteristic sharply delineated white matter (Fig. 2A, B).

Fig. 2 A–M. *Gondolella sublanceolata* Gunnell, component elements of the apparatus, Iowa.

A. Sp element, lateral view, Madison Co., locality 2, sample He-16-3, ROM 30626, × 26.

B. Sp element, lateral view, Madison Co., locality 2, sample He-16-3, ROM 30626, × 27.

C. Oz element, sinistral, outer lateral view, Madison Co., locality 2, sample He-16-3, ROM 30628, × 33.

D. Oz element, dextral, outer lateral view, Madison Co., locality 2, sample He-16-3, ROM 30629, × 33.

E. Lo element, sinistral, outer lateral view, Madison Co., locality 2, sample He-16-3, ROM 30630, × 62.

F. Lo element, dextral, outer lateral view, Madison Co., locality 2, sample He-16-3, ROM 30631, × 67.

G. Hi element, sinistral, outer lateral view, Madison Co., locality 2, sample He-16-3, ROM 30632, × 58.

H. Hi element, dextral, outer lateral view, Madison Co., locality 2, sample He-16-3, ROM 30633, × 43.

I. Ne element, sinistral, outer lateral view, Madison Co., locality 2, sample He-16-3, ROM 30634 × 56.

J. Ne element, dextral, outer lateral view, Cass Co., locality 1, sample He-15-2, ROM 30635. × 48.

K. Syn element, sinistral, inner lateral view, Cass Co., locality 1, sample He-15-3, ROM 30636, × 62.

L. Syn element, dextral, inner lateral view, Madison Co., locality 2, sample He-16-3, ROM 30637, × 44.

M. Tr element, lateral view, Madison Co., locality 2, sample He-16-3, ROM 30638, × 43.

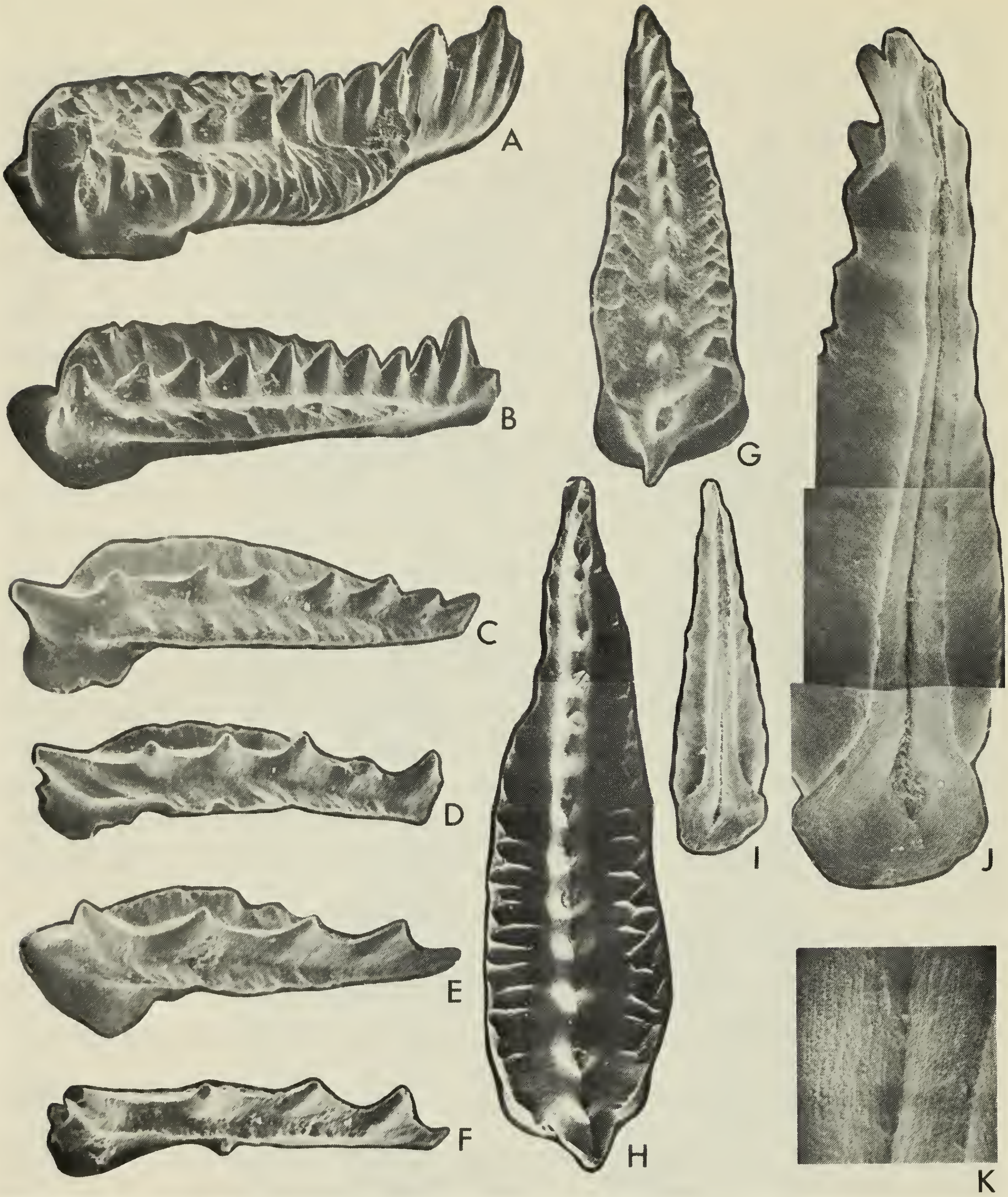


Fig. 3. A–F. *Gondolella sublanceolata* Gunnell, Sp elements, lateral oral view of growth series from largest (3A) to smallest (3F), Iowa.

A. Cass Co., locality 1, sample He-15-2, ROM 30639, × 106.

B. Madison Co., locality 2, sample He-16-3, ROM 30640, × 119.

C. Madison Co., locality 2, sample He-16-3, ROM 30641, × 133.

D. Madison Co., locality 2, sample He-16-3, ROM 30642, × 167.

E. Madison Co., locality 2, sample He-16-3, ROM 30643, × 185.

F. Madison Co., locality 2, sample He-16-3, ROM 30644, × 207.

G–H. *Gondolella sublanceolata* Gunnell, Sp elements, oral view of possible dextral (3G) and possible sinistral (3H) elements, Madison Co., Iowa, locality 2, sample He-16-3.

G. ROM 30645, × 90.

H. ROM 30646, × 73.

I-K. *Gondolella sublanceolata* Gunnell, aboral view, Sp elements, possible sinistral (3I) and dextral (3J) elements, Cass Co., Iowa, locality 1, sample He-15-2.

I. ROM 30647, × 61.

J. ROM 30648, × 119.

K. Enlarged view of basal groove, ROM 30648, × 733.

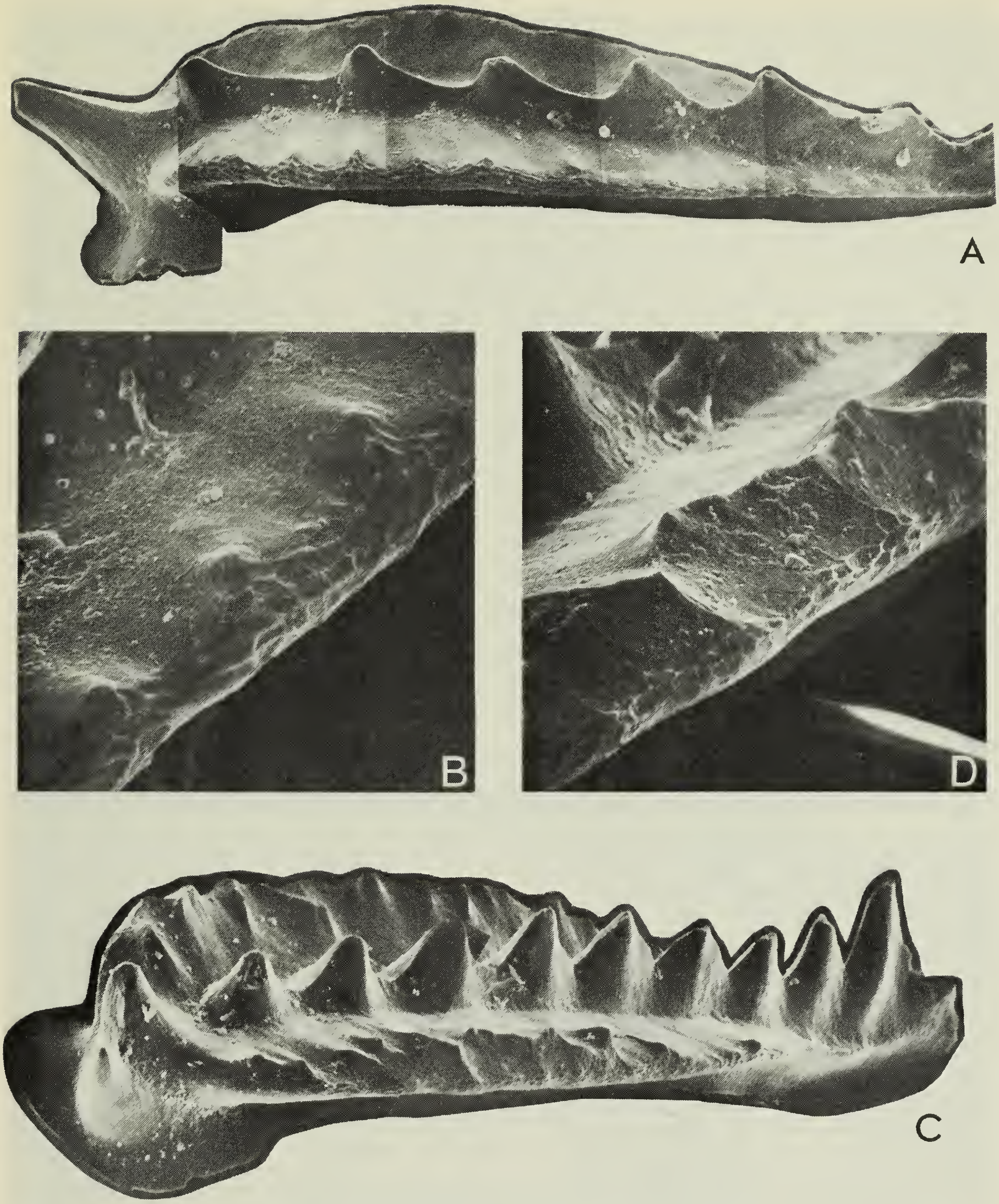


Fig. 4 A-D. *Gondolella sublanceolata* Gunnell, Sp elements, Madison Co., Iowa, locality 2, sample He-16-3.

A. Enlarged lateral oral view, mosaic, ROM 30641, × 222.
B. Enlarged lateral edge, ROM 30641, × 765.
C. Enlarged lateral oral view, mosaic, ROM 30640, × 268.
D. Enlarged lateral edge, ROM 30640, × 618.

Little can be said of the orientation of the basal cavity, since in lateral view it is generally obscured by the platform. In aboral view the basal cavity is defined by a large characteristic loop, which narrows anteriorly into the aboral groove (Fig. 3I, J). Both the basal cavity and the aboral groove show parallel growth lines at high magnifications (Fig. 3K).

Considerable difficulty was experienced in determining the orientation (i.e., dextral or sinistral) of the Sp element. A key to this problem may lie in determination of the direction of the basal groove within the basal cavity. In the two specimens shown (Fig. 3I, J) the groove is directed away from the larger lip of the apron, and these two specimens may represent sinistral and dextral elements, respectively. Other criteria, such as direction and degree of curvature and the orientation and position of the cusp, while not always consistent, also appear to be of possible value (Fig. 3G, H).

The platform shows a most interesting microstructure at high magnification. The "honeycomb pattern" of Lindström (1973: 92) is characteristically developed only on the margins of the platform (Fig. 4), and is not present, as is generally the case on other platform elements (Lindström, 1973), on the oral surface of the platform. This anomalous microstructure distribution on the platform elements may prove to be a defining characteristic of the genus *Gondolella* since the distribution pattern of this structure in *Neogondolella* is distinct, covering much of the oral surface (Fig. 5).

Lindström (1973: 94, fig. 4D) has shown that a microstructure consisting of longitudinal striae is present on the denticles of this element. This microstructure is also present in the specimens on hand and in some of them is more like a loose web-like network, as on the cusp of the specimen shown in Fig. 4A.

Rhodes (1952) recognized that a number of gondolelliform "form species" belonged to the same biological species. Clark and Mosher (1966) attempted to reduce the number of gondolelliform species by placing a number of them, including the type species, *G. elegantula* Stauffer and Plummer, in synonymy. The large collections I have recovered from a restricted interval have convinced me that, while there is obvious morphological variation among the gondolelliform elements having broad platforms, the variation is so subtle that until adequate biometrical studies are made it is best to consider these as the Sp elements of a single species. This approach confirms the conclusions of Rhodes (1952).

Material

1316 specimens; figured specimens ROM 30627, 30628, 30639 to 30648 inclusive.

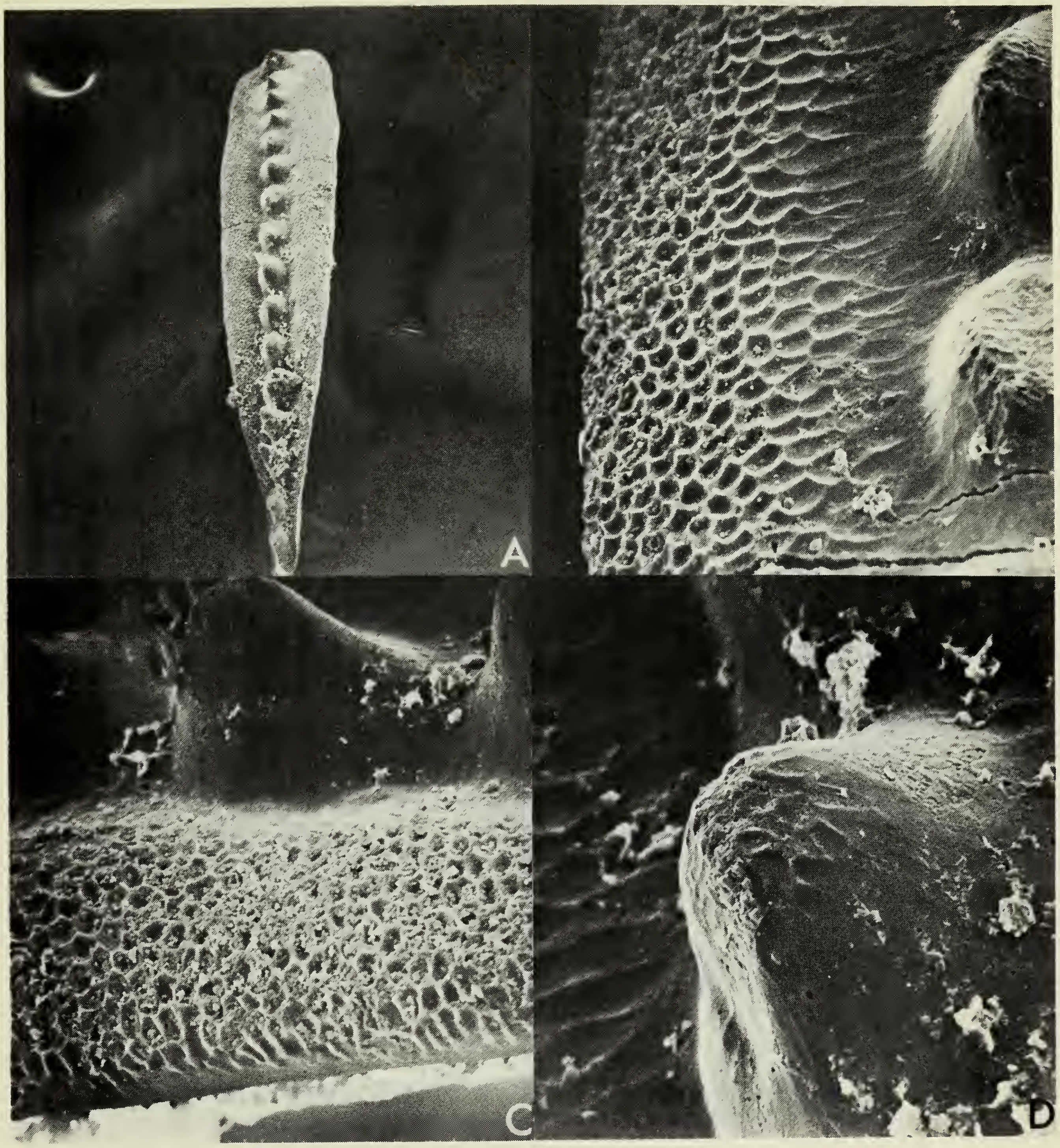


Fig. 5 A–D. *Neogondolella* sp., Ogilvie Mountains, Yukon, Permian, ROM 30649.
A. Oral view, × 73.
B. Oral view of one side of platform, × 602.
C. Oral view, lateral edge, × 579.
D. Oral view, enlarged view of denticle, × 1091.

Oz element (Figs. 2c, d; 6)

Description

This element has been particularly well described as *Prioniodina* ? *camerata* (Gunnell) by Ellison (1941). To this description it can be added that there is little change in the element during growth other than an increase in size and number of denticles. A small element may show as few as six denticles on the anterior bar (Fig. 6c), whereas a large element may have as many as 13 (Fig. 6a).

This element shares with other non-platform elements a microstructure consisting of discontinuous ridges on the denticles (Fig. 6d). This microstructure dies out toward the base of each denticle, and the base is smooth.

Discussion

The following previously described and figured conodonts, which at present cannot be distinguished from the Oz element of *Gondolella sublanceolata*, are interpreted as the Oz elements of species of *Gondolella*:

Euprioniodina sp. B—Stauffer and Plummer, 1932: 32, pl. 2, fig. 34.
Bryantodus cameratus Gunnell, 1933: 268, pl. 32, fig. 47.
Prioniodina ? *camerata* (Gunnell)—Ellison, 1941: 118, pl. 20, figs. 48, 49, 53. [On plate 20, cited as *Prioniodina ? camerata* (Stauffer and Plummer).]
Ozarkodina camerata (Ellison)—Lindström, 1964: 107, fig. 40a.
Gondolella denuda Ellison, Oz element—von Bitter, 1972: 68, pl. 8, fig. 3a, b.
Ozarkodina camerata—Merrill, 1973: fig. 1.

Such an interpretation is supported by natural assemblage material and by the constant association of this element with gondolelliform platforms. That there may be some stratigraphic variation because of evolution is shown by a similar element, the Oz element of *G. gymna* Merrill and King [= *Lonchodina transitans* n. sp. of Merrill and King (1971)]. Other than this, little or no stratigraphic or geographic variation has been documented.

The *G. sublanceolata* Oz element is easily distinguished from the Oz element of species of *Streptognathodus* and *Idiognathodus* (von Bitter, 1972; Baesemann, 1973) by its short, weak posterior bar, by its characteristic anteriorly directed basal cavity (Fig. 2c, d), by its white matter distribution (Fig. 2c, d), and by the sharply flaring apron or lip on the outer side of the element (Fig. 6). It can be differentiated from the Hi element of G. *sublanceolata*, with slightly greater difficulty, by the fact that the latter generally lacks the sharply flaring apron or lip, is arched to a greater degree, has a stronger posterior bar, and has a basal cavity that is longer and curves with the cusp (Fig. 2g, h).

Material

264 sinistral, 296 dextral, and 1 orientation indeterminate specimens; figured specimens ROM 30628, 30629, 30650 to 30654 inclusive.

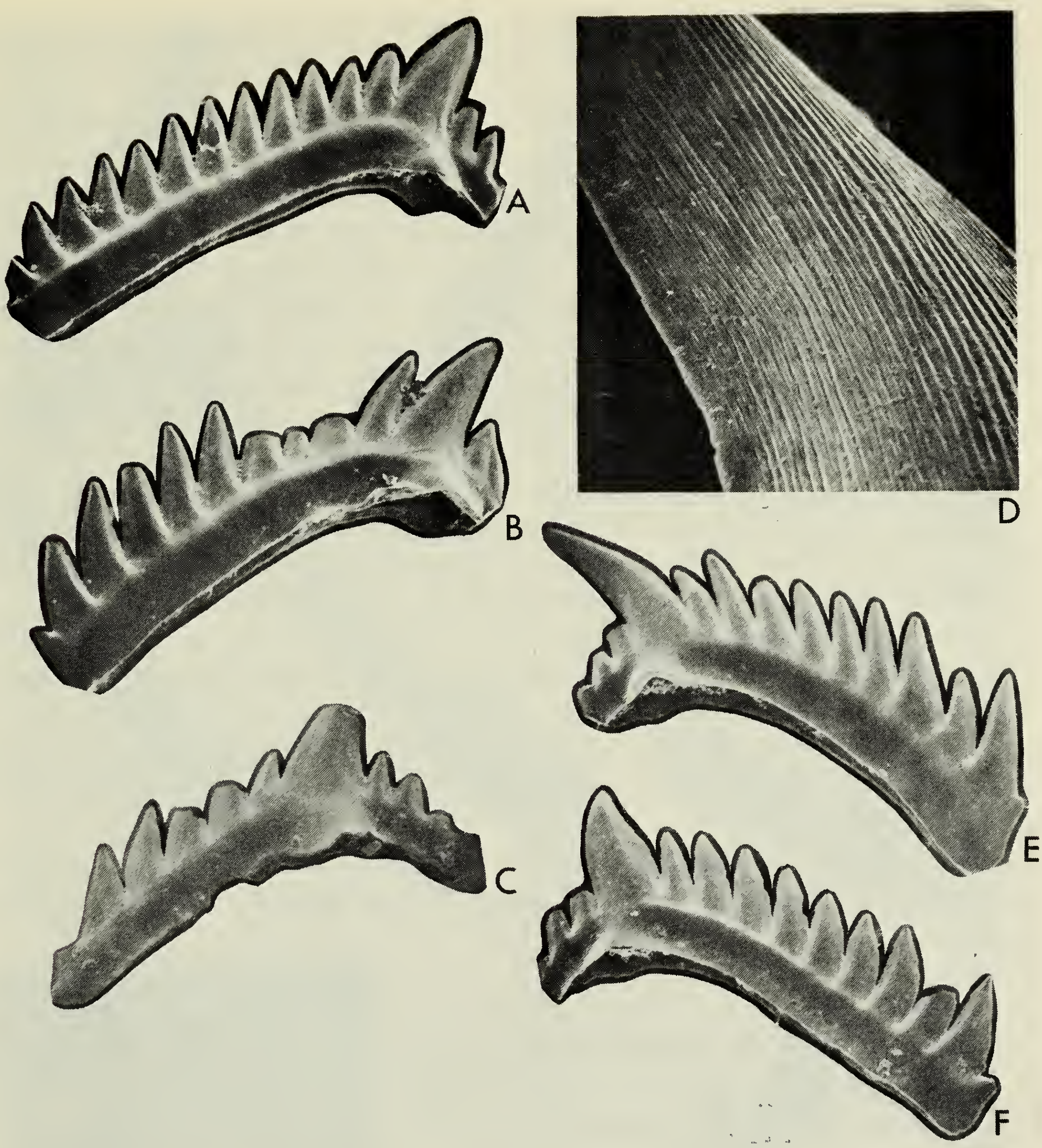


Fig. 6 A–F. *Gondolella sublanceolata* Gunnell, Oz elements, outer lateral view, Iowa.

A. Sinistral, Madison Co., locality 2, sample He-16-3, ROM 30650, × 99.

B. Sinistral, Madison Co., locality 2, sample He-16-3, ROM 30651, × 116.

C. Sinistral, Madison Co., locality 2, sample He-16-3, ROM 30652, × 115.

D. Enlarged view of cusp, Cass Co., locality 1, sample He-15-3, ROM 30653, × 628.

E. Dextral, ROM 30653, × 92.

F. Dextral, Cass Co., locality 1, sample He-15-3, ROM 30654, × 130.

Lo element (Figs. 2E, F; 7)

Description

A spicule-like element dominated by a long cusp and possessing two downward directed lateral bars. The two bars are generally incompletely preserved. The anterior bar is the stronger of the two and up to four discrete, slightly posteriorly curving, laterally compressed denticles have been observed on this bar. The posterior bar is weaker and up to three denticles, similar to but shorter than those of the anterior bar, have been observed on this bar. The outer side of this element is noticeably rounded with the bars deflected inward and downward. The inner side is gently concave (Fig. 7H). A slight lip is present at the base of the element on the outer side (Fig. 7A). The cusp is long, curved posteriorly, round on the outer side, and flattened and scoop-like on the inner side (Fig. 7H). The basal cavity when seen in lateral view (Fig. 2E, F) is shaped like an inverted V and is directed anteriorly at a noticeable angle to the cusp. Seen aborally, the basal cavity narrows and passes into the anterior and the posterior bars as a narrow but deep aboral groove. A short distance above the basal cavity tip of the cusp, well-demarcated white matter starts. In some specimens above a white matter "ring" the cusp is clear, and in some specimens a central "train" of triangular white matter may be seen. The upper halves of the bar denticles are white and translucent, whereas the bottom halves are clear and of an amber colour. This clear amber colour also characterizes the element below the denticles.

At high magnification the denticles and cusp of this element show a microstructure of discontinuous striae, which die out near the base of each cusp (Fig. 7F).

Discussion

Previously I have considered a morphologically indistinguishable element to be the Hi? element of *Gondolella denuda* Ellison (von Bitter, 1972). This should now be the Lo element. The specimen identified as *Hindeodella* sp. by Ellison (1941: pl. 20, fig. 19) seem morphologically identical to the Lo element of *G. sublanceolata*, as does the specimen illustrated by Merrill (1973), fig. 1) as *Lonchodina?* n. sp. 11. These conodonts are probably the Lo components of other species of *Gondolella*.

The *Gondolella sublanceolata* Lo element, while probably similar or identical to the Lo element of other species of *Gondolella*, is dissimilar to elements belonging to other Pennsylvanian conodont species. It is, however, remarkably similar morphologically to many species placed in the genus *Enantiognathus* Mosher and Clark by Mosher (1968), Kozur (1968), and Kozur and Mostler (1970).

Material

200 sinistral, 192 dextral, and 29 orientation indeterminate specimens; figured specimens ROM 30631, 30632, 30655 to 30661 inclusive.

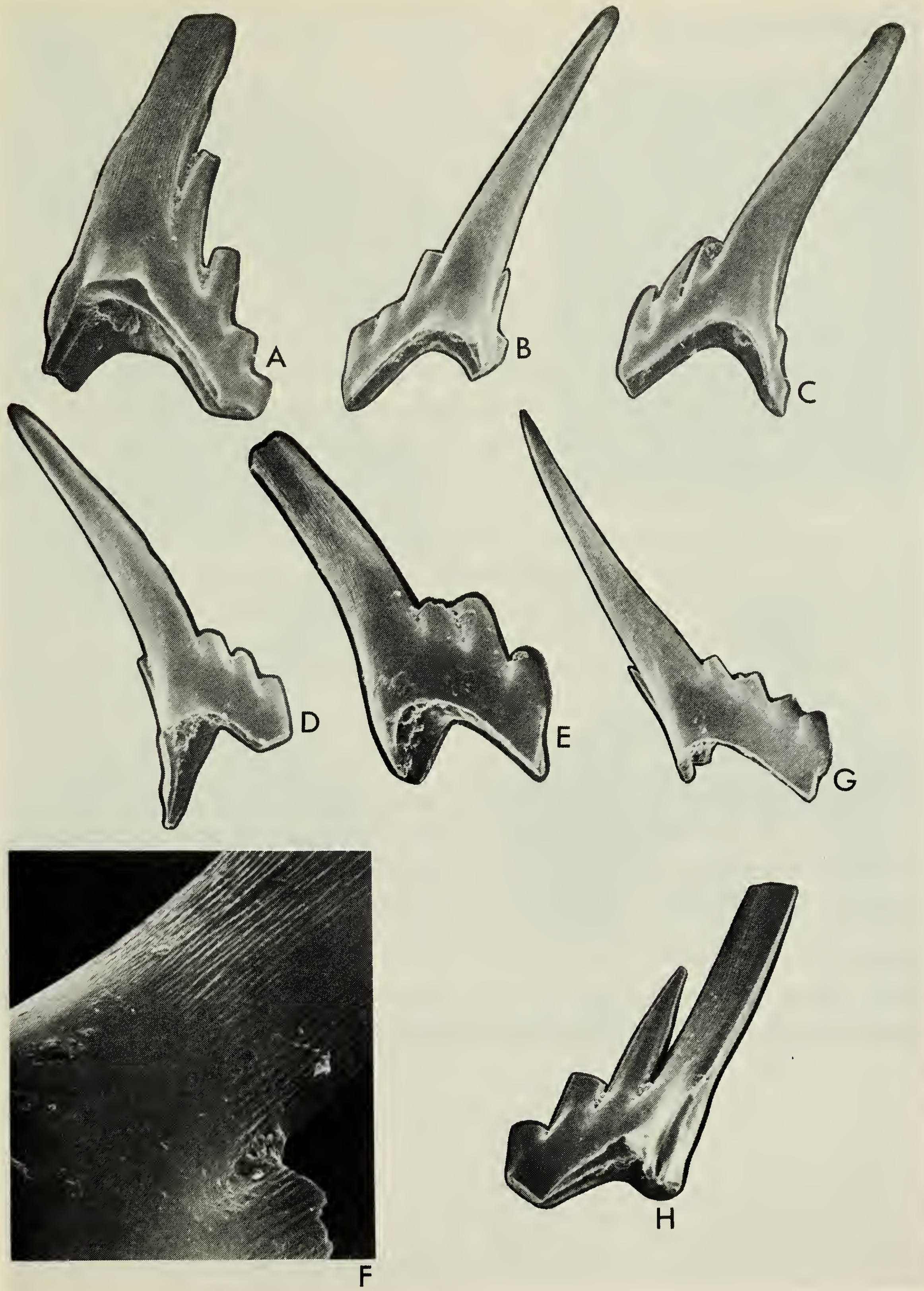


Fig. 7 A–H. *Gondolella sublanceolata* Gunnell, Lo elements, outer (A–G) and inner (H) lateral view, Madison Co., Iowa, locality 2, sample He-16-3.

A. Sinistral, ROM 30655, × 155.
B. Sinistral, ROM 30656, × 113.
C. Sinistral, ROM 30657, × 131.
D. Dextral, ROM 30658, × 107.
E. Dextral, ROM 30659, × 162.
F. Enlarged view of basal portion of cusp, ROM 30659, × 585.
G. Dextral, ROM 30660, × 118.
H. Dextral, ROM 30661, × 135.

Hi element (Figs. 2G, H; 8)

Description

A strongly arched element bearing long anterior and posterior bars, both of which are missing on most specimens due to breakage. The element is only slightly flexed laterally and may bear a small lip or apron on the other side. The anterior and posterior bars have been observed to bear a maximum of nine and six discrete denticles, respectively. The anterior bar denticles, in particular, are noticeably curved in a posterior direction (Fig. 8A). The cusp is approximately twice the length of the other denticles, is straight, and is laterally compressed so that its anterior and posterior edges are sharp. The basal cavity, in lateral view, is shaped like an inverted V and is directed anteriorly; however, its tip, unlike that of the Oz or Lo element, curves with the cusp (Fig. 2G, H). In aboral view, the basal cavity narrows away from the cusp and both the anterior and posterior bars bear a narrow but deep aboral groove. The upper half of the cusp is milky white in colour due to the presence of white matter. The sharp line of demarcation is just above the basal cavity tip. The upper halves of the anterior and posterior bar denticles are generally white and translucent whereas their lower halves and the entire base to which they are connected are clear and are a characteristic amber colour.

A microstructure of discontinuous striae is present on the denticles and on the cusp (Fig. 8B).

Discussion

This element may be distinguished from the similar *Gondolella sublanceolata* Oz element by the fact that it usually lacks a prominent sharply flaring apron, is arched to a greater degree, has a basal cavity tip that curves with the axis of the cusp, and possesses long anterior and posterior bars.

Material

304 sinistral, 284 dextral, and 15 orientation indeterminate specimens; figured specimens ROM 30632, 30633, 30662 to 30665 inclusive.

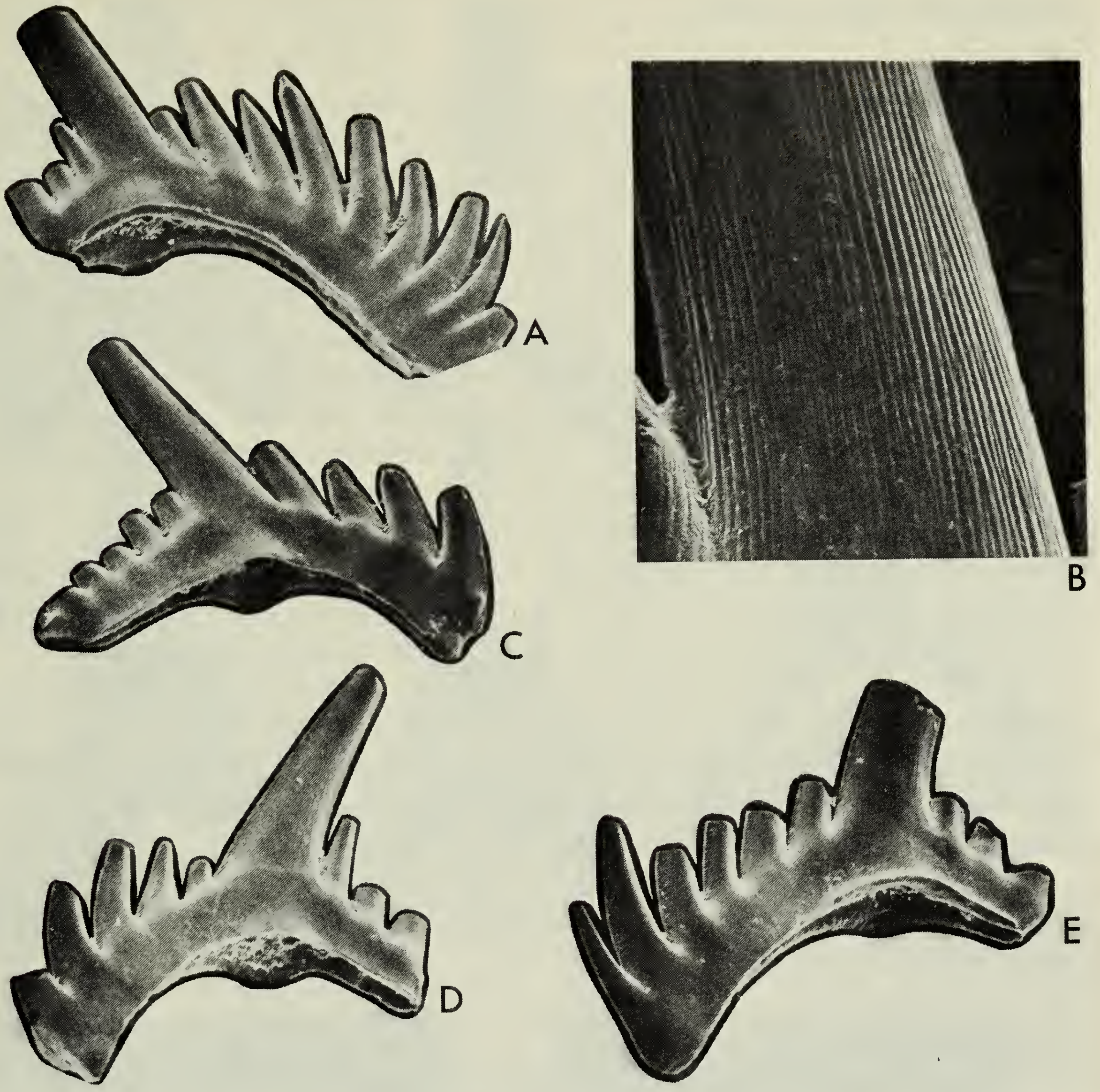


Fig. 8 A–E. *Gondolella sublanceolata* Gunnell, Hi elements, inner lateral view, Cass Co., Iowa, locality 1, sample He-15-3.

A. Sinistral, ROM 30662, × 120.
B. Enlarged view of cusp, ROM 30662, × 643.
C. Sinistral, ROM 30663, × 132.
D. Dextral, ROM 30664, × 171.
E. Dextral, ROM 30665, × 188.

Ne element (Figs. 2I, J; 9)

Description

An element possessing a large flaring rounded apron on the inner side, a weakly denticulated anterior bar, and a more strongly denticulated posterior bar. The sharp anterior edge of the cusp continues into the large aborally directed scoop-like anterior bar whose denticles are so small, particularly in small specimens, that at first glance the bar often appears to be adenticulate and sharp edged. The posterior bar, which is stronger than the anterior bar, is also directed aborally and has been observed to bear up to four inward curving and posteriorly inclined discrete denticles. The cusp also curves inward and may curve posteriorly very slightly (Fig. 2I, J). The cusp is laterally compressed, being almost scoop-like, and bears a keel-like flange along its edges (Fig. 9G). The large flaring apron is located posteriorly relative to the axis of the cusp so as to make the element asymmetrical. In lateral view (Fig. 2I, J) the basal cavity is large and shaped like an inverted V, and is sharply directed anteriorly at an angle to the axis of the cusp. In aboral view the basal cavity narrows and continues into the bars as a narrow but deep basal groove.

Immediately above the basal cavity tip there is usually a sharp line of demarcation above which the cusp is composed of white matter. In some specimens there are clear areas within this white matter. The upper halves of the anterior and posterior bar denticles are similarly composed of white matter. Below the white matter the element is clear and of an amber colour.

Like other ramiform elements of this apparatus the denticles, including the cusp, have a microstructure of discontinuous striae that die out near the base of each cusp (Fig. 9E-G).

Discussion

The only Pennsylvanian conodonts with which this element may be confused are small specimens of *Idioprioniodus conjunctus* Ne element [=*Neoprioniodus conjunctus*, Ne element of von Bitter, 1972] and the *Gondolella sublanceolata* Syn element. It differs from the former by possessing a number of anterior bar denticles, characteristic white matter distribution, a large anteriorly directed basal cavity, and a cusp that is directed both inward and posteriorly. In addition the maximum size reached by the Ne element of *I. conjunctus* is much larger than that of this element. The criteria for distinguishing this element from the *G. sublanceolata* Syn element are given under the description of the latter (p. 20).

Material

137 sinistral, 163 dextral, and 13 orientation indeterminate specimens; figured specimens ROM 30634, 30635, 30666 to 30671 inclusive.

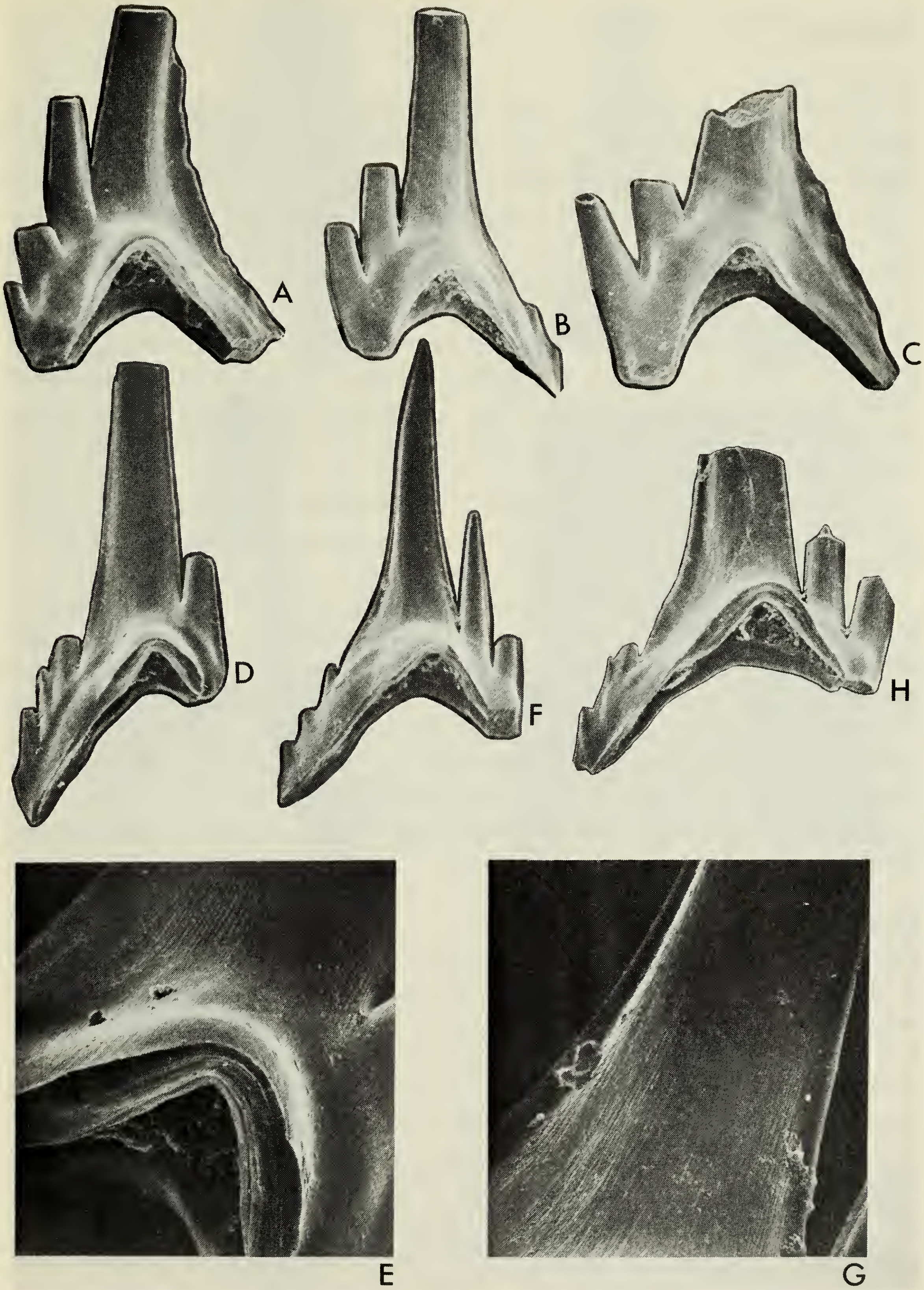


Fig. 9 A–H. *Gondolella sublanceolata* Gunnell, Ne elements, inner lateral view, Cass Co., Iowa, locality 1, sample He-15-3.

A. Sinistral, ROM 30666, × 186.
B. Sinistral, ROM 30667, × 182.
C. Sinistral, ROM 30668, × 258.
D. Dextral, ROM 30669, × 161.
E. Enlarged view of cusp, ROM 30669, × 497.
F. Dextral, ROM 30670, × 176.
G. Enlarged view of cusp, ROM 30670, × 590.
H. Dextral, ROM 30671, × 235.

Syn element (Figs. 2K, L; 10)

Description

An element possessing a large, sharp edged, keeled apron on the inner side, a short denticulated anterior bar, and a longer denticulated posterior bar. The dagger-shaped anterior bar is directed aborally and bears four or more short, poorly defined denticles. The aborally directed posterior bar is longer than the anterior bar and has been observed to bear as many as six inward curving denticles. The inward curving, slightly twisted cusp is also posteriorly inclined; it is laterally compressed to be almost subtriangular and is often noticeably scoop-like (Fig. 10A, F). The flaring apron is sharp edged, particularly in small and intermediate sized specimens, so much so that in some specimens there is a physical break (Fig. 10B). The sharp edge of the apron curves posteriorly and is located directly over the basal cavity. The sharp edge continues up the cusp as a median keel (Fig. 10C). Seen in lateral view, the deep basal cavity is shaped like an inverted V and is directed posteriorly at an angle to the direction of the cusp. In aboral view the basal cavity narrows and continues as a narrow but deep basal groove both anteriorly and posteriorly.

The white matter of the cusp is not segregated as clearly in many specimens of this element as it is in those of the other elements of the apparatus. The cusp of larger specimens may be made up of wispy rather than solid white matter. In many smaller specimens the "white cap" distribution is normal (Fig. 2K, L) and the upper portion of the bar denticles, particularly of the longer posterior bar denticles, is composed of white matter. Below the white matter the element is clear and of an amber colour.

At high magnification the striations on the cusp and on the denticles are apparent (Fig. 10C).

Discussion

The only element with which this element may be confused is the Ne element of this species. These two elements are morphologically very similar and, indeed, G. K. Merrill (pers. comm., 1975) has suggested that they represent a symmetry transition. The Syn element may be distinguished from the Ne element by its sharp edged inner apron and the keel present on the cusp of some specimens. The correct orientation of this element is problematical. This element, unlike the remaining ramiform elements of the apparatus, bears a basal cavity that is oriented posteriorly (Fig. 2K, L), i.e., toward the strong posterior bar. While it is possible that the stronger bar may be the anterior bar (as in the Lo and the Oz elements), this is considered unlikely since this also affects the orientation of the similar Ne element, whose basal cavity orientation is consistent with that of the other ramiform elements.

I have previously pointed out (von Bitter, 1972: 60) the discrepancy between the concept of *Synprioniodina microdenta* of Ellison (1941) and that applied to this species by later authors, as for example Higgins and Bouckaert (1968) and Baesemann (1973). The holotype (University of Missouri C556-1) and one paratype (University of Missouri C81-5) are interpreted to be the Syn element of a species of *Gondolella*. The other figured paratype (University of Missouri C79-3) is interpreted to be the Ne element

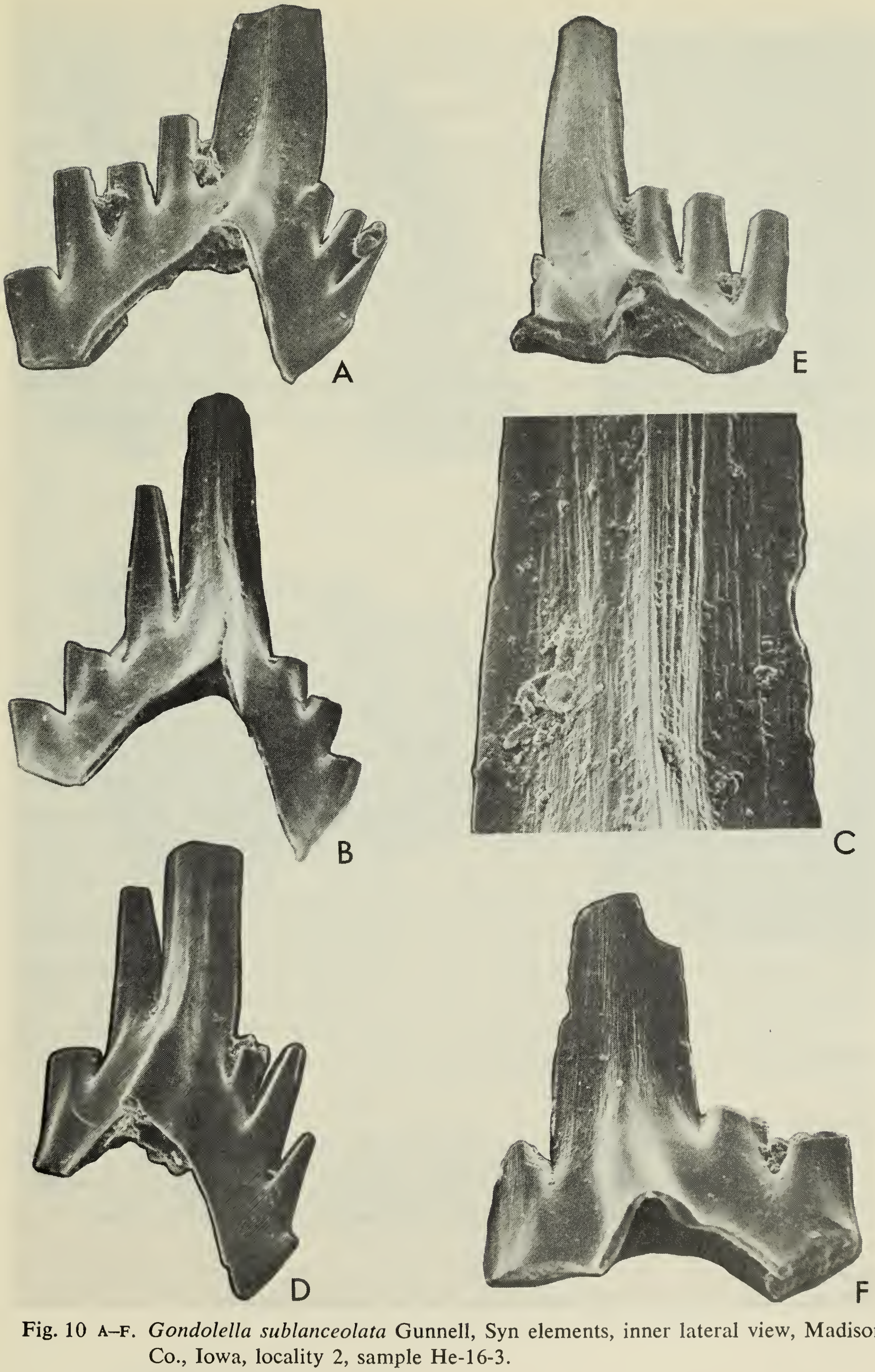


Fig. 10 A–F. *Gondolella sublanceolata* Gunnell, Syn elements, inner lateral view, Madison Co., Iowa, locality 2, sample He-16-3.

A. Sinistral, ROM 30672, × 220.
B. Sinistral, ROM 30673, × 255.
C. Enlarged view of cusp, ROM 30673, × 1075.
D. Sinistral, ROM 30674, × 256.
E. Dextral, ROM 30675, × 180.
F. Dextral, ROM 30676, × 338.

of a species of *Gondolella*. The unfigured paratype (University of Missouri C490-3) may be the only specimen among the types that is identical with what later authors have called *S. microdenta*, but this cannot be demonstrated because of poor preservation. The synprioniodiniform element that has been called *S. microdenta* by many authors is the Ne element of species of *Idiognathodus* and *Streptognathodus* (von Bitter, 1972; Baesemann, 1973) and is distinguished from the "true" *S. microdenta* by being more asymmetrical, having a characteristic apron on the inner side, and by generally possessing denticulation consisting of alternating large and small denticles.

Material
198 sinistral, 205 dextral, and 28 orientation indeterminate specimens; figured specimens ROM 30636, 30637, 30672 to 30676 inclusive.

Tr element (Figs. 2M; 11)

Description
A bilaterally symmetrical element bearing a long, rarely preserved posterior bar. The lower two-thirds of the element is clear amber in colour; the upper two-thirds of the cusp and most of the smaller denticles are a milky white colour (Fig. 2H), with some minor clear areas. The element is dominated by a large posteriorly inclined cusp that is subtriangular in cross section, with a flat anterior surface and two lateral bevels (Fig. 11B). The anterior bars, like the posterior bar, are rarely preserved, are short, bear only one to three denticles, and are directed both anteriorly and aborally. The denticles are discrete and are peg-like, particularly in larger specimens. The large basal cavity is directed anteriorly at a noticeable angle to the cusp (Fig. 2M). The basal cavity narrows into the anterior and posterior bars as a deep but narrow basal groove (Fig. 11E).

The cusp and denticles of this element possess a microstructure consisting of both parallel and anastomosing striations (Fig. 11B–D).

Discussion
This element is easily distinguished from the Tr element of species of *Cavusgnathus*, *Streptognathodus*, *Idiognathodus*, and *Idioprioniodus* by its basal cavity, its characteristic denticulation, and the distribution of its white matter.

Material
105 specimens; figured specimens ROM 30638, 30677, 30678.

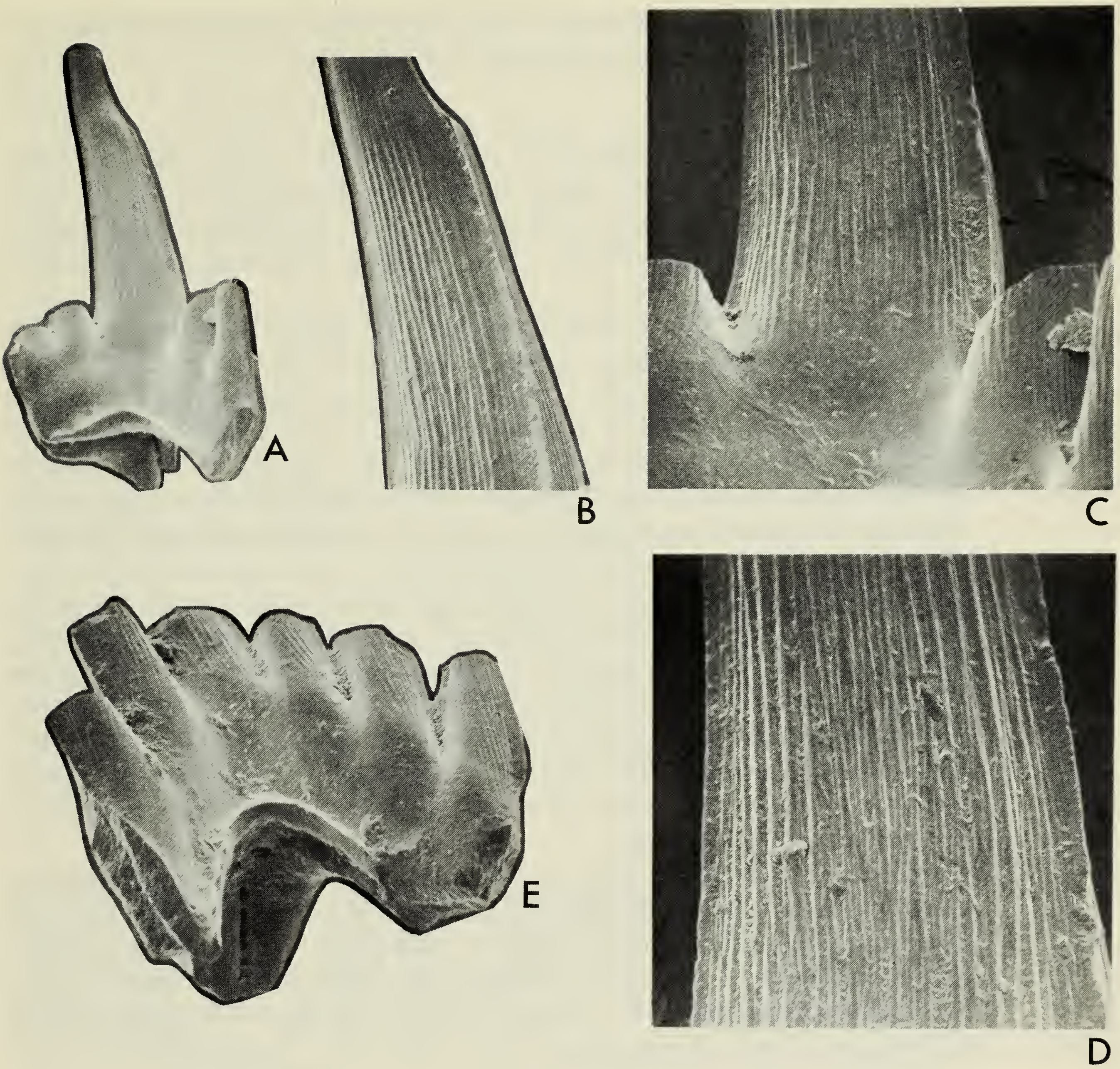


Fig. 11 A–E. *Gondolella sublanceolata* Gunnell, Tr elements, Cass Co., Iowa, locality 1, sample He-15-3.

A. Lateral view, ROM 30677, × 176.
B. Enlarged view of upper cusp, ROM 30677, × 390.
C. Enlarged view of base of cusp, ROM 30677, × 544.
D. Enlarged view of cusp, ROM 30677, × 944.
E. Anterior aboral view, ROM 30678, × 325.

Relation of the Apparatus of Gondolella sublanceolata *Gunnell to that of* Illinella typica *Rhodes*

Illinella is a monotypic genus and the type species, *I. typica*, came from the Middle Pennsylvanian Mecca Quarry Shale (Collinson et al., 1972). It was described by Rhodes (1952) as containing one pair of gondolelliform elements, four pairs of lonchodiform elements, and two pairs of lonchodiniform elements (Fig. 12).

The holotype of *Illinella typica*, specimen X-1505 (Fig. 13A), which has recently been carefully cleaned and excavated by R. D. Norby of the Illinois State Geological Survey, bears two gondolelliform Sp elements. It also bears an Ne or Syn element, which although not identical to the *G. sublanceolata* Ne or Syn elements does have certain characteristics, i.e., the angle of the basal cavity and the restriction of the white matter to the upper part of the cusp and the denticles, that make it possible to conclude that it probably was part of the same apparatus as the two gondolelliform elements.

A rather interesting aspect of the type specimen is that two of the paired elements identified by Rhodes (1952) as lonchodiform elements have been identified by R. D. Norby and G. K. Merrill (pers. comm., 1975) as a pair of neognathodiform platform elements. Closely associated with the two neognathodiform elements are the posterior bar of a Tr element, an Oz element, and fragments of one or more Hi elements. The latter three element types, together with the two platforms, are interpreted as representing an incomplete apparatus of a species of *Neognathodus.*

Paratype X-1506 (Fig. 13B) shows a pair of gondolelliform Sp elements (one is present only as an external mould of the basal groove), three Oz elements (one of which is questionable), an Hi element, and abundant unidentifiable fragments. All of these elements are morphologically similar to the corresponding elements in *G. sublanceolata* and it is likely that these elements all belonged to one apparatus.

Paratype X-1507 (Fig. 14A) bears a pair of gondolelliform Sp elements and five ramiform elements. The latter consist of an Ne element, an Ne or Syn element, an Oz element, an Lo element, and a Tr element, and although these can only questionably be identified they are morphologically similar to similarly designated elements in the apparatus of *G. sublanceolata.* Consequently, all of these elements are believed to have been borne by one animal. In addition to unidentifiable fragments, there are two elements, including an Ne element, that are interpreted as belonging to the apparatus of a species of *Idioprioniodus* (sensu Baesemann, 1973 and Merrill and Merrill, 1974).

Paratype X-1508 (Fig. 14B) shows a single gondolelliform element, an Oz element, and an Ne or Syn element, as well as abundant comb-like fragments. Again, comparison with the apparatus of *G. sublanceolata* permits me to conclude that these elements are probably all part of the same animal.

The remaining two paratypes do not bear gondolelliform Sp elements. The first, specimen X-1503 (Fig. 15A), shows a single Ne element associated with two blade fragments, possibly those of two Oz elements. The second, specimen X-1504 (Fig. 15B), shows a Syn element, a possible Tr element, and a possible

Oz element (mostly as an external mould), as well as several blade fragments. The elements present on these two specimens are here interpreted as having belonged to a species of *Gondolella.*

Thus it has been possible to identify elements in the type specimens of *Illinella typica* Rhodes morphologically similar to those belonging to *Gondolella sublanceolata.* Although Rhodes did not report or identify Oz, Lo, Hi, and Tr elements in *I. typica,* the Oz element and elements identical or similar to the Lo, Hi, and Tr elements can be discerned in these natural assemblages. The paired Oz elements can be seen particularly well (Fig. 16) in Field Museum specimen W.M. 44602 [= Assemblage 2 of Jones, MS 1938]. In this specimen a pair of gondolelliform Sp elements is clearly associated with a pair of Oz elements, as well as with unidentifiable fragmentary remains (cf. Jones, 1956: fig. 7.2).

Rhodes' recognition of two pairs of lonchodiniform elements in *I. typica* is reasonable, and they appear to correspond to the Ne and Syn elements of *Gondolella sublanceolata.* The four pairs of lonchodiform elements recognized by Rhodes (1952) either represent fragmentary remains of blade and bar elements making up parts of the apparatus, or else, as is the case with the holotype, may represent broken elements of the apparatuses of other species, such as those of *Idioprioniodus* and *Neognathodus.* The fact that there are abundant unidentifiable comb-shaped fragments present seems to me to be a normal circumstance.

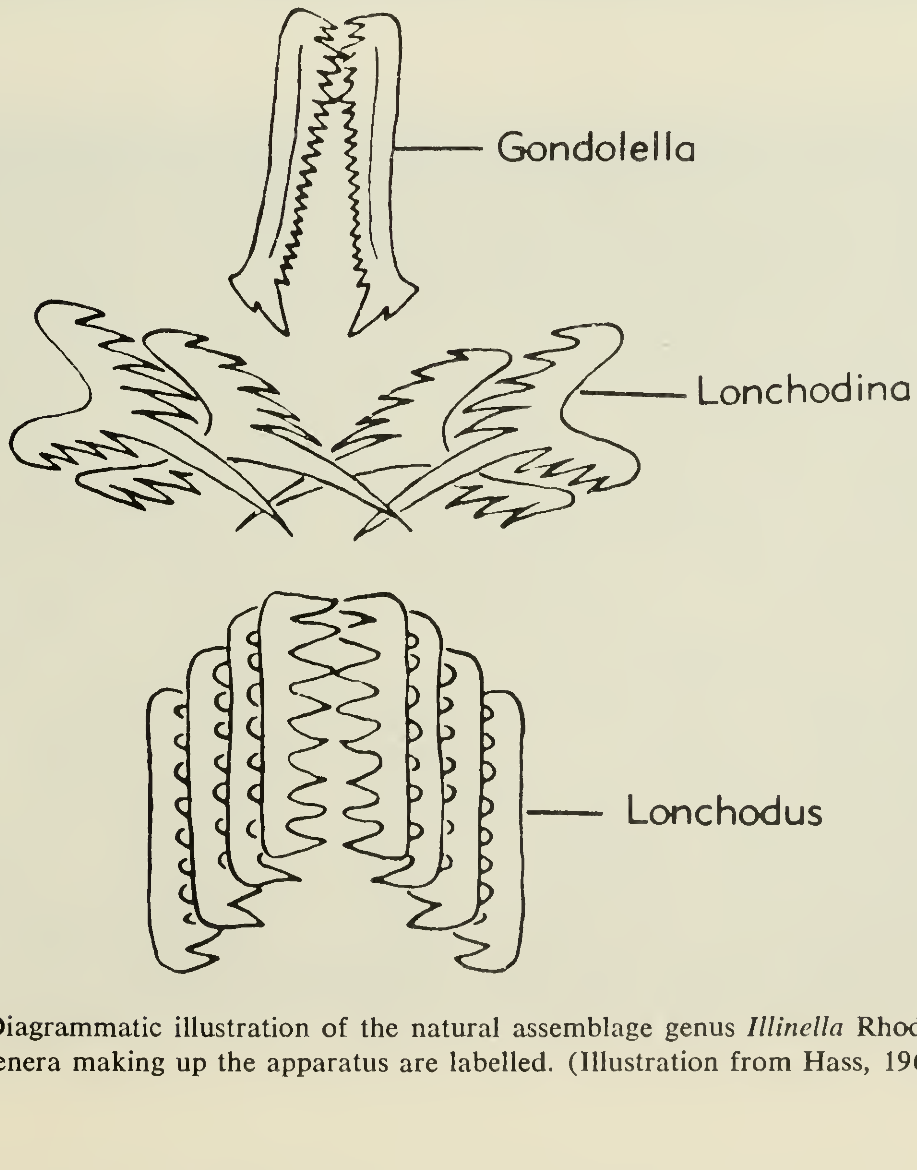


Fig. 12 Diagrammatic illustration of the natural assemblage genus *Illinella* Rhodes. Form genera making up the apparatus are labelled. (Illustration from Hass, 1962.)

For example, in another apparatus, that of species of *Idioprioniodus* [= *Neoprioniodus* of von Bitter, 1972], one normally observes only elements that lack anterior and posterior bars associated with abundant comb-like fragments. Under exceptional circumstances these are preserved (Fig. 17).

It is reasonable to conclude that *Illinella typica* and *Gondolella sublanceolata* not only had a corresponding element composition but also had ramiform elements which, if not totally identical, were certainly very similar.

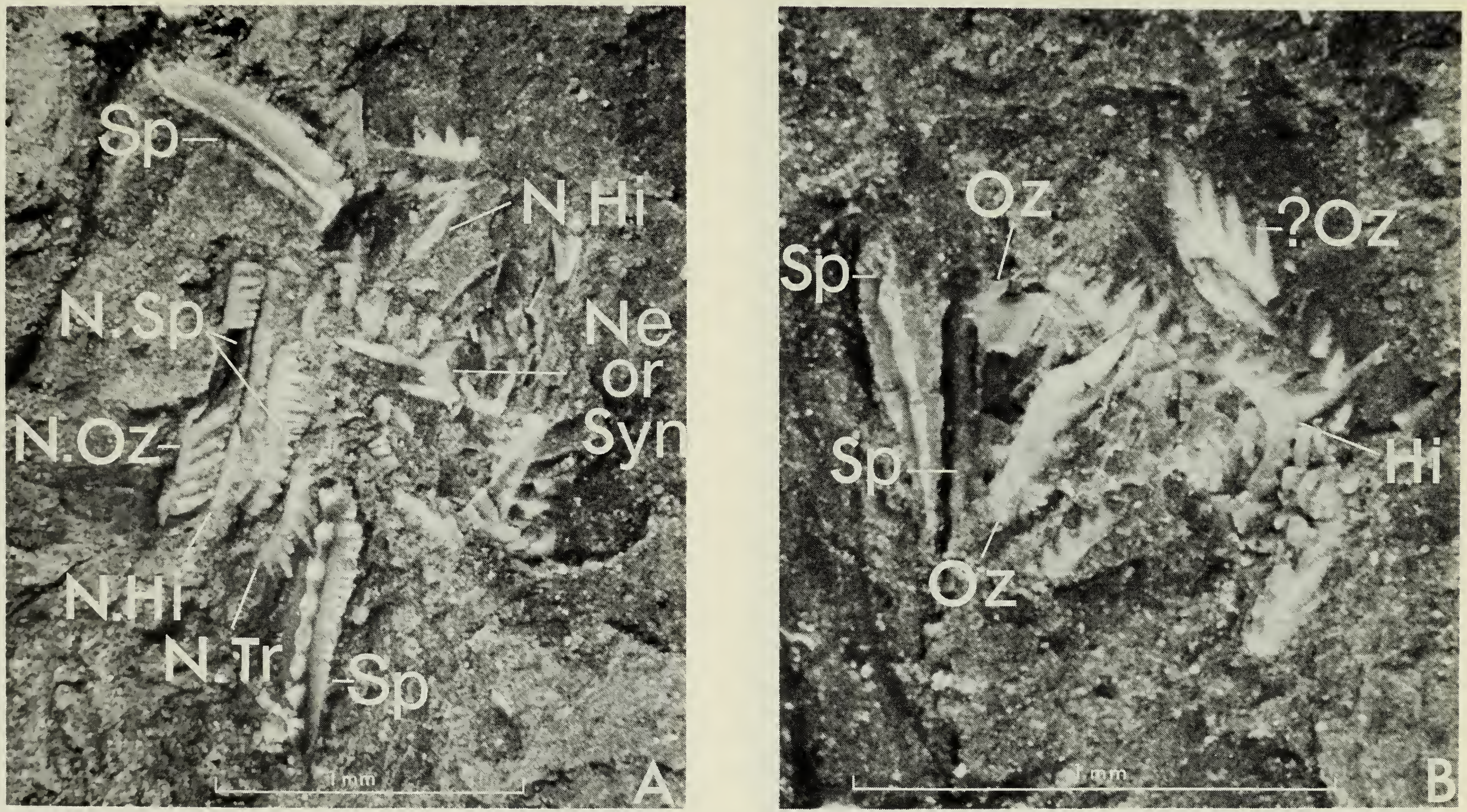


Fig. 13 A–B. *Illinella typica* Rhodes, holotype and paratype, Adams Co., Illinois, Mecca Quarry Shale (Middle Pennsylvanian).
A. N. designates elements interpreted to belong to the apparatus of a species of *Neognathodus*. Holotype, University of Illinois X–1505.
B. Paratype, University of Illinois X–1506.

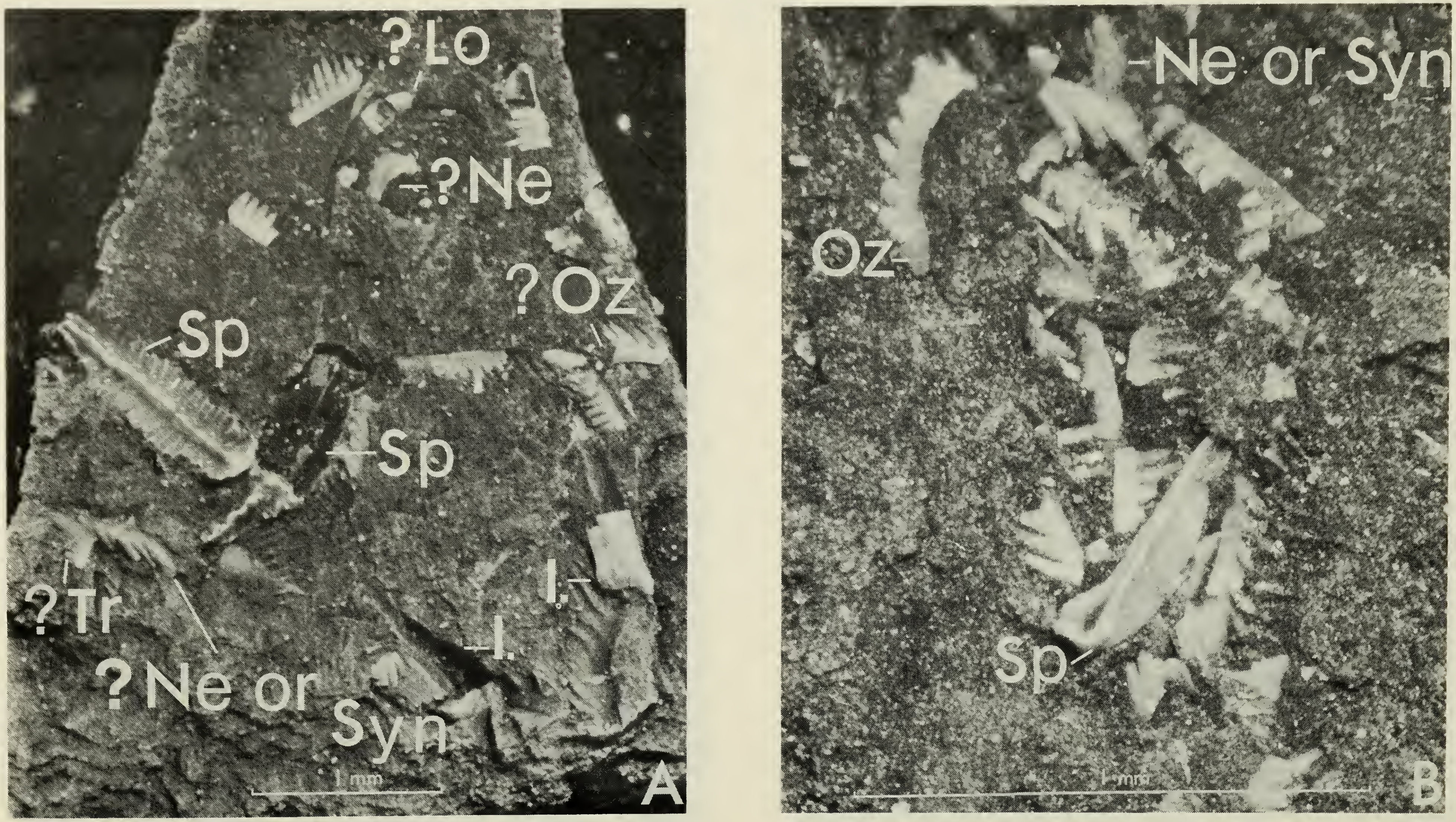


Fig. 14 A–B. *Illinella typica* Rhodes, paratypes, Adams Co., Illinois, Mecca Quarry Shale (Middle Pennsylvanian).
A. I. designates elements interpreted to belong to the apparatus of a species of *Idioprioniodus*, University of Illinois X–1507.
B. University of Illinois X–1508.

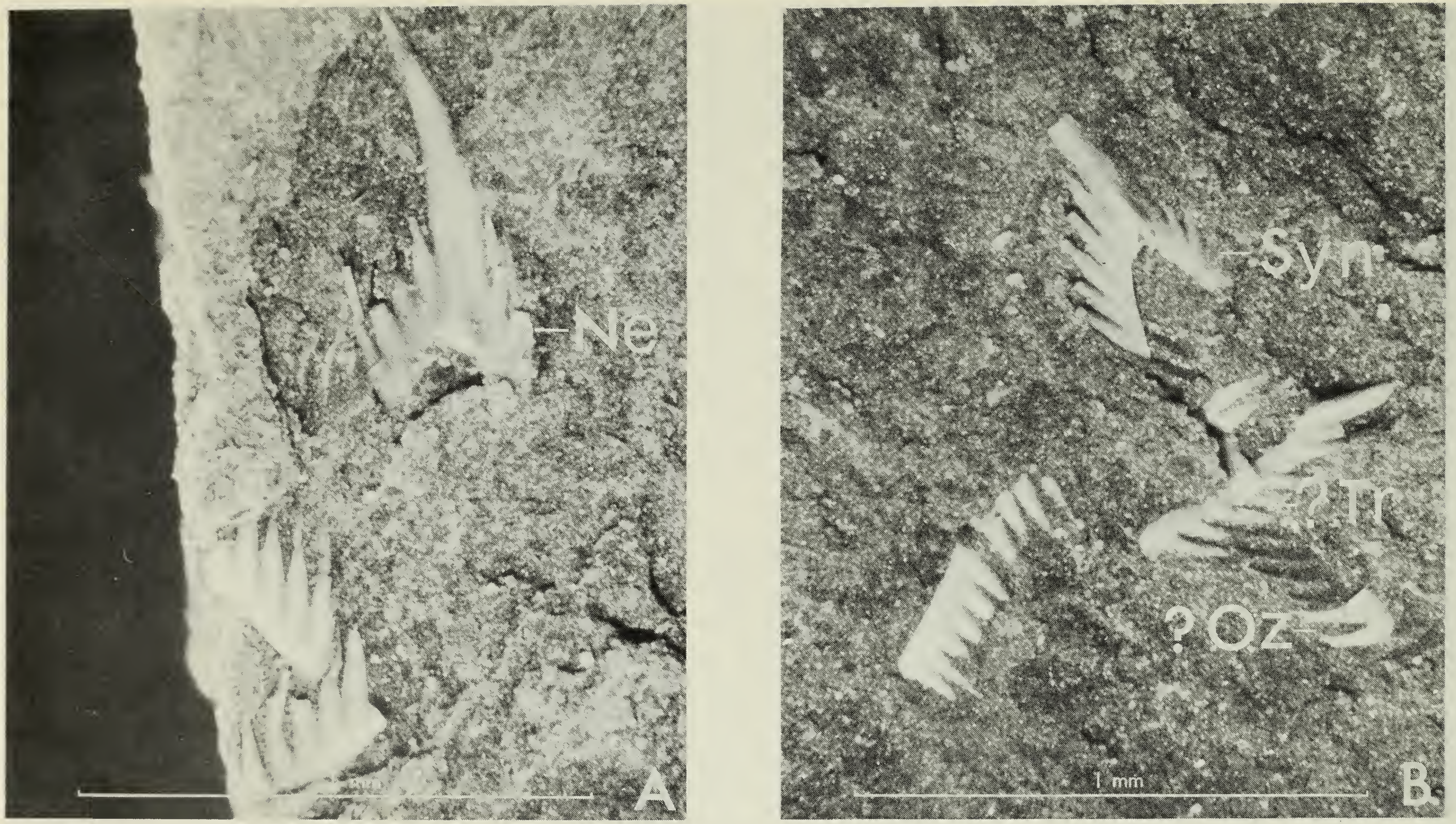
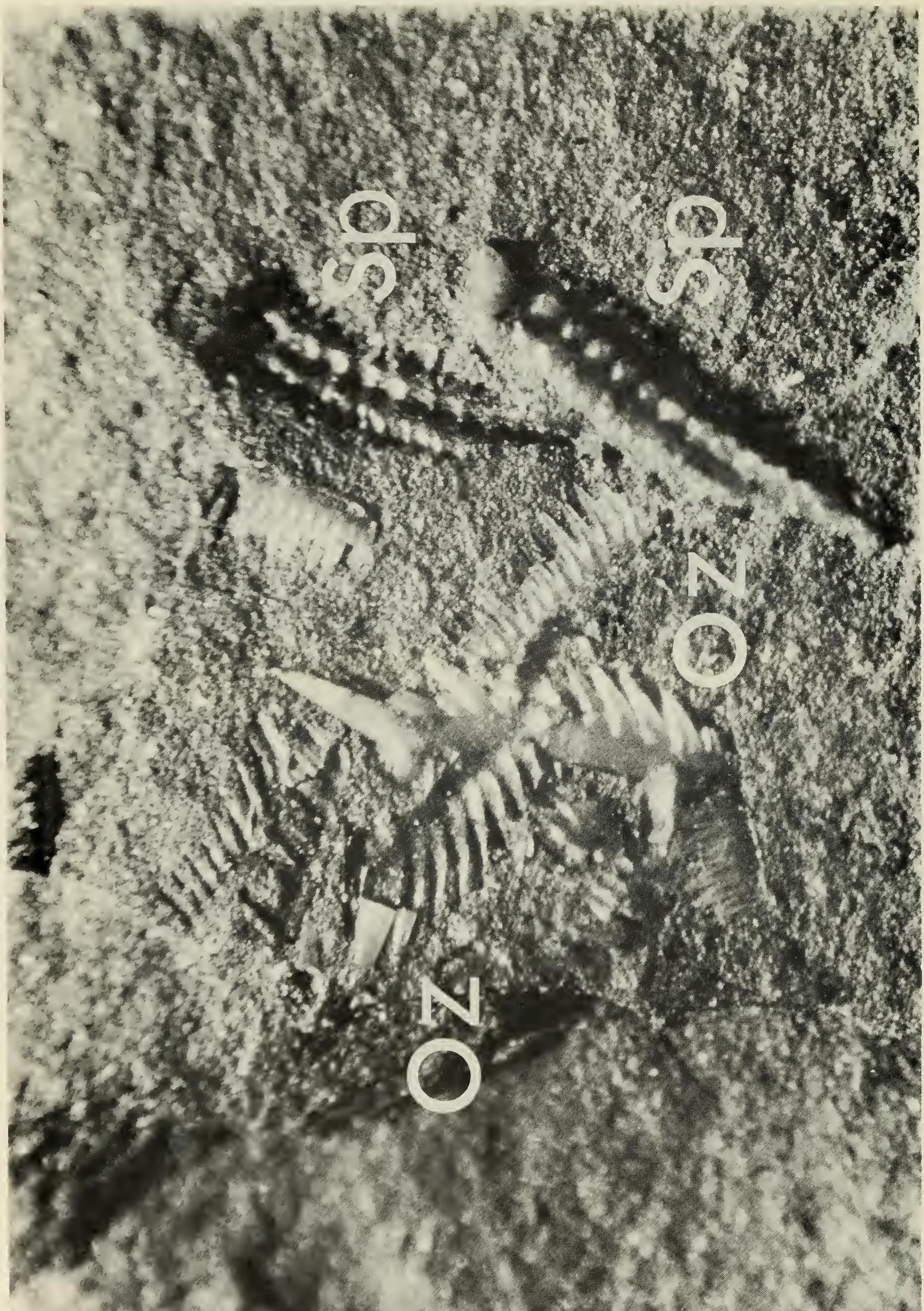


Fig. 15 A–B. *Illinella typica* Rhodes, paratypes, Adams Co., Illinois, Mecca Quarry Shale (Middle Pennsylvanian).
A. University of Illinois X–1503.
B. University of Illinois X–1504.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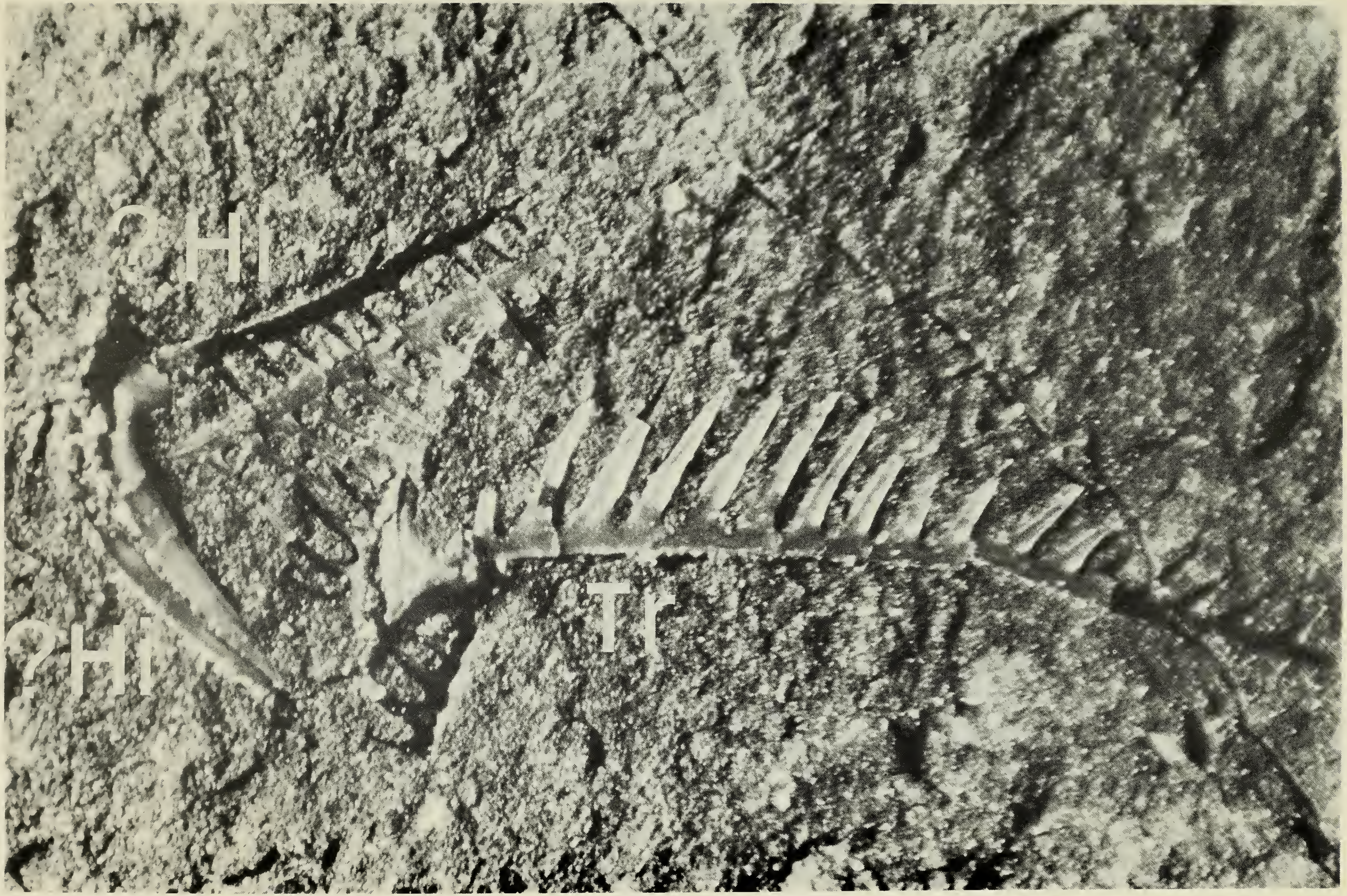

Fig. 17 *Idioprioniodus* sp., incomplete natural assemblage showing Tr element with long posterior bar and a pair of probable Hi elements, Sarpy Co., Nebraska, Stark Shale Member (Missourian), ROM 30679, × 37.

The Position of the Apparatus of Gondolella *in Apparatus Classification*

The element composition of *Illinella* Rhodes has always been problematical when compared with other Carboniferous platform-bearing apparatuses such as those of *Idiognathodus* and *Streptognathodus* [= *Scottognathus* Rhodes] and *Cavusgnathus* [= *Lewistownella* Scott]; i.e., the Class A assemblages of Rhodes (1962). Rhodes (1962: W73) noted that the apparatus lacked "the pick-shaped blades of Class A assemblages" and recognized that this "may be the result of nonpreservation in the known specimens of the genus". The result of this lack was that the elements of the *Illinella* apparatus did not obviously correspond to those of other apparatuses. This led to the suggestion by Druce et al. (1974: 393) that *Illinella* "appropriately might be regarded as a distinct natural family, within a common natural order with 'Class A' type assemblages" should the apparatus lack pick-shaped blades.

The element composition of *G. sublanceolata*, as well as that of the natural assemblage material, suggests that the pick-shaped blades referred to by Rhodes (1962) are present in *Illinella typica* in the form of the Ne and Syn elements. Klapper and Philip (1971) placed the Class A assemblages of Rhodes (1962) in the Type 1 apparatus of their classification. Rhodes (1962) recognized that the gondolelliform Sp element was dissimilar to that of Class A assemblages [= Type 1]. Further, the discrete denticulation of the ramiform elements of *G. sublanceolata* and the general morphological dissimilarity of the ramiform elements to those of Type 1 apparatuses make such an assignment untenable for this species.

The *Gondolella sublanceolata* Oz, Lo, and Hi elements correspond fairly well to the O_2, B_3, and B_2 elements, respectively, of the Type 2 apparatus of Klapper and Philip (1971). The N element of the Type 2 apparatus may correspond to the Ne and Syn elements of *G. sublanceolata*. However, the presence in *G. sublanceolata* of both an atypical Sp element and a well-developed bilaterally symmetrical Tr element prevents designation of its apparatus as a member of Type 2.

It would seemingly make sense to classify the apparatus of *G. sublanceolata* as a Type 3 apparatus, i.e., the same type to which the apparatus of species of *Idioprioniodus* would belong; not only because species of *Gondolella* and *Idioprioniodus* had similar environmental requirements and restrictions (von Bitter, 1972), but also because their ramiform elements have similar denticulation and both apparatuses possessed a bilaterally symmetrical element. However, the presence of a platform element in the apparatus of *G. sublanceolata* and the absence of such an element in *Idioprioniodus* and other Type 3 apparatuses prevent such a classification.

The platform element is morphologically most similar to platform elements of apparatuses placed in the *Icriodontidae* (Type 4) by Klapper and Philip (1972). The ramiform elements of *G. sublanceolata* are most similar in their denticulation and in their overall morphology to the ramiform elements of species of Cryptotaxidae (Type 2) and Hibbardellidae (Type 3).

Thus, whereas the apparatus of *G. sublanceolata* does not fit into the Type 1 apparatus model, it does have characteristics of all three of the remaining apparatus types proposed by Klapper and Philip (1971).

Merrill and King (1971) reported the oldest known species of *Gondolella*, *G. gymna*, a species lacking a platform, from the Seville Member of northwestern Illinois. G. K. Merrill (pers. comm., 1975) believes this unit to be of Upper Atokan age. As to whether or not early gondolelliform element-bearing species had ramiform elements in their apparatuses, it is pertinent to note that *G. gymna* had at least an Oz element, if my interpretation is correct (von Bitter, 1972).

The lower limit of the occurrence of species of *Gondolella* having a platform was given by Clark and Mosher (1966) as Middle Desmoinesian. Although more data on Desmoinesian species of *Gondolella* are necessary, some of the best information on the apparatus of *Gondolella* in this part of the stratigraphic column was provided by Rhodes (1952). The natural assemblages studied by Rhodes (1952) were considered earlier. It is of interest to note that the gondolelliform elements described and figured by Rhodes were all of the broad-platform type and were associated with elements that are clearly ramiform elements.

Missourian gondolelliform elements with broad platforms were probably also associated biologically with the ramiform elements. I have noted previously (von Bitter, 1972) that the gondolelliform conodonts which were reported by Stauffer and Plummer (1932) from the Missourian of Texas were likely associated with non-platform elements in a multi-element conodont apparatus. Sweet (*in* Ziegler, 1973) has observed that the same general sort of association can be demonstrated between species of *Gondolella* and *Prioniodina* ? *camerata* using the data of Ellison (1941) for Desmoinesian, Missourian, and Virgilian conodonts.

Baesemann (1973), restudying Missourian conodonts of northeast Kansas, tabulated the distribution of species of *Gondolella* as well as of an element he identified as *Prioniodina* ? *obtusa* Ellison. His distribution charts indicate a close association between these elements, a conclusion supported by cluster analysis of his data (Fig. 18). *Prioniodina* ? *obtusa* of Baesemann (1973: pl. 1, figs. 3, 7) clearly represents one or more ramiform elements of a species of *Gondolella* and is understandably grouped with gondolelliform platform elements in the cluster analysis. A more specific identification of the elements from the illustrations is not possible; however, in both figures the characteristic distribution of white matter and orientation of the basal cavity can be seen. The upper part of the dendrogram (Fig. 18) groups the elements of the *Idioprioniodus* apparatus. It is surprising that the conodont *Hindeodella parva* clusters in here because *H. parva* is now known to be a part of the apparatus of one or more species of *Streptognathodus* and *Idiognathodus* (M. Avcin, pers. comm., 1972). The close association of the components of two apparatuses (i.e., *Gondolella* and *Idioprioniodus*) in the dendrogram is interpreted as reflecting the similar environmental requirements of species of *Gondolella* and of *Idioprioniodus*.

Finally, that Missourian gondolelliform elements with broad platforms had a number of ramiform elements in their apparatuses can be confirmed by examining a natural assemblage from the lowermost Missourian of Oklahoma, immediately above the Desmoinesian–Missourian boundary, in the Seminole Formation (Oakes, 1952; Jewett et al., 1968). This specimen (Fig. 16) bears two

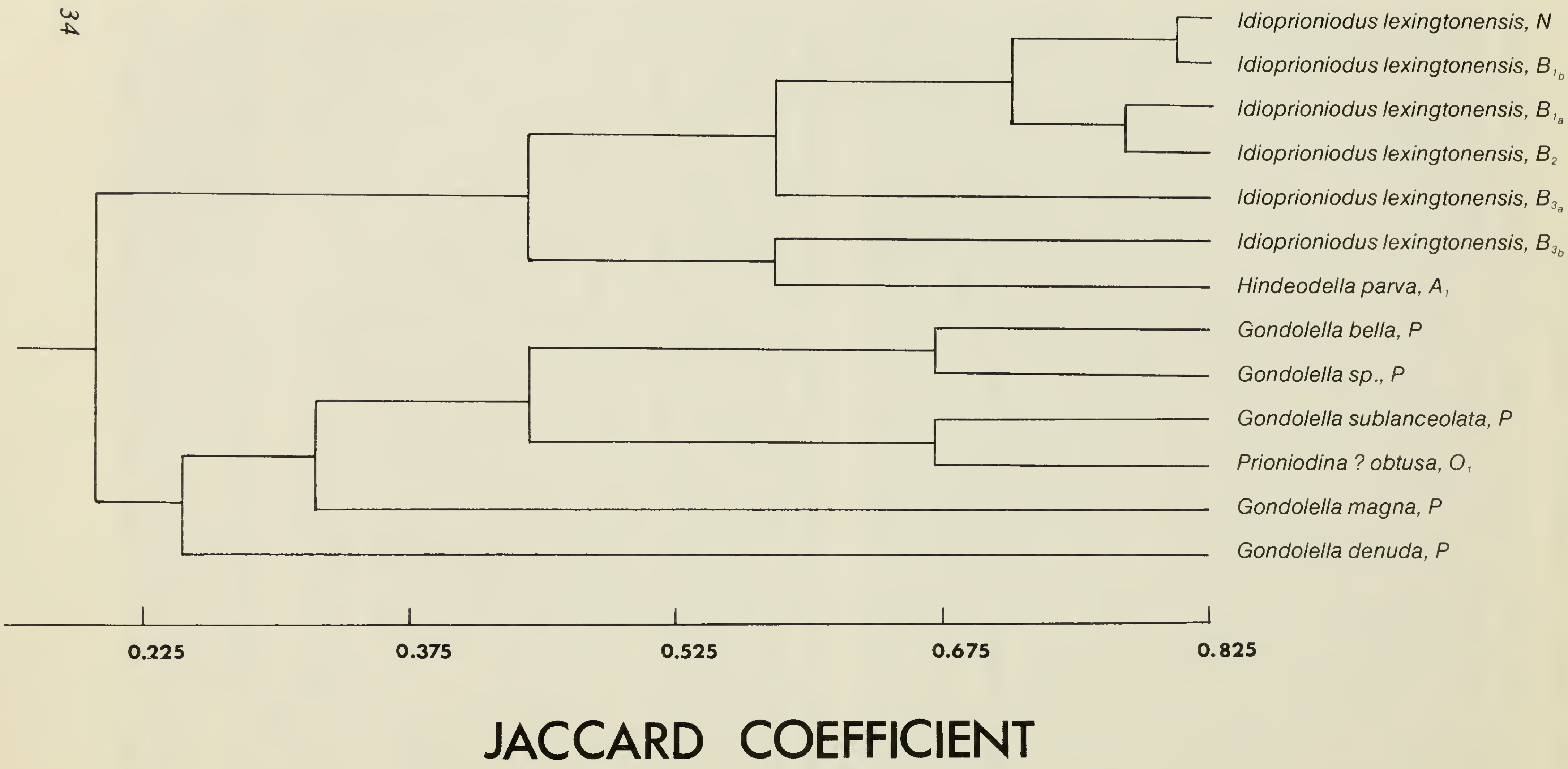

Fig. 18 Selected portion of dendrogram of R-mode cluster analysis of distributional data of Baesemann (1973) (converted to presence-absence) using Jaccard coefficient, and the unweighted pair group (UPGMA) clustering method. Cophenetic correlation coefficient is 0.779. Taxonomic terminology is that of Baesemann (1973).

gondolelliform elements with broad platforms associated with a pair of Oz elements.

In the Virgilian, gondolelliform elements lacking a well-defined platform had ramiform elements as part of their apparatuses (von Bitter, 1972). Whether this is true for gondolelliform elements having a well-developed platform is uncertain. If the two sections studied in this report are of Virgilian age (see Appendix) then this would also be the case for Virgilian gondolelliform elements with broad platforms.

The only reported stratigraphically higher occurrence of a species of *Gondolella* s.s. of which I am aware is that of *G. bella* from the Lower Wolfcampian of Nevada (Clark, 1972, 1974). Because of a paucity of bars and blades in these faunas Clark (1972) suggested that this species may have had a single element apparatus.

Although more work is required, particularly on Virgilian and younger faunas, there is the suggestion that, throughout most or all of its time range, the apparatus of *Gondolella* varied little, i.e., in addition to bearing gondolelliform Sp elements of either type it contained a number of paired bar and blade elements. The apparatus of *G. sublanceolata*, consisting of six paired element types and a single bilaterally symmetrical element, can probably be taken as representative for use as an element blueprint for species of *Gondolella*, notwithstanding the fact that the apparatus of the type species, *G. elegantula*, has yet to be reconstructed. It seems likely that within this element plan species of *Gondolella* will continue to be defined on the basis of differences in the platform elements and not by differences in the associated ramiform elements.

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Dr. Glen Merrill not only made me aware of locality 2 by first sending me a sample from this locality, but he also generously provided unpublished information on his studies of Pennsylvanian conodont faunas.

Finally, I am indebted to Mr. Ray Burchett of the Nebraska Geological Survey, Lincoln, for valuable discussions on structural and stratigraphic problems in Nebraska and Iowa.

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Appendix

Identification of the Heebner Shale at Localities 1 and 2

Since the early work by Condra and Upp (1933a, b) the strata at localities 1 and 2 have consistently been identified as belonging to the Lower and Middle Oread Formation (e.g., Evans, MS 1966; Toomey, 1969; Troell, 1969; see also the references in Tables 2 and 3). While I am presently unable to demonstrate that this identification is not correct, it should be noted that the conodont faunas of the Heebner Shale at these two localities are distinct from those of the Heebner at localities in other states. The most noticeable difference lies in the presence of the very abundant *Gondolella sublanceolata* Gunnell at these two localities (Table 1). At other sampled localities of the Heebner in Iowa, Missouri, Kansas, and Oklahoma species of *Gondolella*, although not absent as reported previously (von Bitter, 1972), are very rare and are invariably *Gondolella denuda* Ellison, whose platform element lacks the broad platform of other species. I explained these distributional differences as different biofacies within the Heebner (von Bitter, 1973). While this may indeed be the case an alternative explanation may be that these beds have been consistently misidentified over the years.

Structurally, the area is more complex than similar areas in Missouri and Kansas and consists of well-delineated domes and shallow synclines (see Hershey et at., 1960: 55; Welp et al., 1968: 4–1). In this sort of structural situation lithologically similar units of different megacyclothems may easily be confused. Thus, for example, at locality 2, the black shale identified as the Heebner may be the Eudora Shale of the Stanton Formation, a not unreasonable possibility in light of the fact that the Stanton has been identified (Welp et al., 1968) in the uppermost portion of the nearby Stanzel Quarry (NW SE sec. 5 T75N R29W Madison Co., Iowa), and that the Eudora Shale has been found to contain a very similar conodont fauna to that reported here to occur at localities 1 and 2 (Ellison, 1941; Baesemann, 1973).

Table 1. Distribution of the elements of the apparatus of *Gondolella sublanceolata* Gunnell in the Heebner Shale at localities 1 and 2. Sample He-15-2 incompletely picked.

	Locality 1			Locality 2			Totals	
	He-15-1	He-15-2	He-15-3	He-16-1	He-16-2	He-16-3		
Gondolella sublanceolata, Sp element	–	394	339	3	183	397		**1316**
Gondolella sublanceolata, Oz element								
Sinistral	–	54	45	–	53	112	264	
Dextral	–	74	70	1	39	112	296	
Indeterminate	–	1	–	–	–	–	1	
		129	115	1	92	224		**561**
Gondolella sublanceolata, Lo element								
Sinistral	–	44	46	–	37	73	200	
Dextral	–	47	47	1	38	59	192	
Indeterminate	–	7	8	–	3	11	29	
		98	101	1	78	143		**421**
Gondolella sublanceolata, Hi element								
Sinistral	–	47	94	–	47	116	304	
Dextral	–	56	83	–	42	103	284	
Indeterminate	–	–	–	–	–	15	15	
		103	177	–	89	234		**603**

Table 1, cont.

	Locality 1			Locality 2			Totals	
	He-15-1	He-15-2	He-15-3	He-16-1	He-16-2	He-16-3		
Gondolella sublanceolata, Ne element								
Sinistral	–	22	33	1	27	54	137	
Dextral	–	39	31	–	30	63	163	
Indeterminate	–	1	2	–	–	10	13	
		62	66	1	57	127		313
Gondolella sublanceolata, Syn element								
Sinistral	–	43	53	–	38	64	198	
Dextral	–	43	53	–	27	82	205	
Indeterminate	–	4	16	–	5	3	28	
		90	122	–	70	149		431
Gondolella sublanceolata, Tr element	–	21	31	1	16	36		105
Gondolella, Unidentifiable element	–	25	55	–	23	6		109
	0	922	1006	7	608	1316		3859

Table 2. Locality and sample register.

		Sample code	Thickness in.	Thickness cm	Description
Locality:	1				Contact with underlying Leavenworth Limestone not exposed.
Location:	SE NE sec. 16, T75N R37W Cass Co., Iowa	He-15-1	3″	7.6 cm	Shale, brown, poorly bedded, clayey, calcareous; upper 1″ gray and transitional with overlying black shale; small brachiopods present; contact with underlying Leavenworth Limestone not exposed due to flooding; estimate 4–6″ to top of Leavenworth.
Description:	(after Toomey, 1969) Exposure at a rock cut in the Nishnabotna River just outside town of Lewis.				
Stratigraphic Unit Sampled:	Heebner Shale Member				
Previous References:	Condra and Upp (1933a): Lewis Section—Columnar Section 4 Hershey et al. (1960, p. 53) Toomey (MS 1964, 1969): locality 27.	He-15-2	8″	20.3 cm	Shale, black, fissile; uppermost portion gets softer and more clayey; no fossils observed.
	Evans (MS 1966): locality 2.	He-15-3	1′9″	53.3 cm	Shale, olive green, poorly bedded, clayey; uppermost 1′5″ more sandy and more pebbly; green shale containing crinoid columnals and brachiopods.
					Contact with overlying Plattsmouth Limestone (9′10″ exposed).

Table 3. Locality and sample register.

		Sample code	Thickness in.	cm	Description
Locality:	2				Contact with underlying Leavenworth Limestone (1′0″ exposed).
Location:	SW NW sec. 7, T75N R29W Madison Co., Iowa	He-16-1	6½″	16.5 cm	Shale, lower 3″ light grey; upper 3½″ becomes darker and increasingly fissile; small brachiopods scattered throughout.
Description:	(after Toomey, 1969) Exposure on north side of stream bed approximately 150 yards east of north-south trending county road.	He-16-2	1′0″	30.5 cm	Shale, black, fissile; no fossils observed.
		He-16-3	1′5½″	44.5 cm	Shale, chocolate brown, clayey; lower two-thirds blocky becoming increasingly more fissile and black downwards, uppermost one-third becomes increasingly lighter upward; uppermost 3-4″ is sandy greenish-brown blocky shale containing brachiopod fragments.
Stratigraphic Unit Sampled:	Heebner Shale Member				
Previous References:	Condra and Upp (1933b) Immediately adjacent to section 5 (Fig. 3 of Condra and Upp) Toomey (MS 1964, 1969): locality 29 Troell (MS 1965, 1969): locality 32 Evans (MS 1966): locality 1 Welp et al, (1968): Stop 6				Contact with overlying Plattsmouth Limestone (15′1½″ exposed).

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